APPENDIX H-3

Identify and Outline Measures to Control Playa Emissions

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APPENDIX H-3
IDENTIFY AND OUTLINE MEASURES TO CONTROL PLAYA EMISSIONS

The main focus of this technical memorandum is the development of dust control approaches for future Exposed Playa Areas at the Salton Sea. Other air quality issues, such as emissions of fugitive dust (PM_{10}) from Exposed Playa, and dust and exhaust emissions from construction and operations and maintenance of facilities associated with the alternatives, are addressed in Chapter 10 of the Programmatic Environmental Impact Report (PEIR), with supporting information provided in Appendix E.

The alternatives would involve varying amounts and configurations of exposed Salton Sea Bed (called "playa"). Under the alternatives, the playa would be either developed for some land use (e.g., wildlife refuge, brine storage) or managed to limit dust emissions. Where no other land use is specified, Exposed Playa would be specified for Air Quality Management, a land use in which the main purpose of facilities and land management is to control dust emissions. Air Quality Management could take the form of either long term monitoring (for stable areas) or dust control (for areas that require it). The rationale for and configuration of these facilities, as presented here, provides design criteria and operations requirements to incorporate Air Quality Management into the alternatives.

Under the State Water Resources Control Board (SWRCB) Order and the Imperial Irrigation District (IID)'s Water Conservation and Transfer Project Mitigation, Monitoring, and Reporting Program, (MMRP) (IID, 2003; SWRCB, 2002), potential air quality impacts from exposed Salton Sea playa must be monitored and mitigated by implementing the following four steps:

1. Restrict future access. Minimize disturbance of natural crusts and soil surfaces in exposed shoreline areas;
2. Research and monitoring. Conduct research to find effective and efficient dust control measures for the Exposed Playa, and monitor the surrounding air quality;
3. Emission reduction credits. If monitoring results indicate exposed areas are emissive, create or purchase offsetting emissions reductions; and
4. Dust control measures. To the extent that offsets are not available, implement dust control measures on the emissive parts of the Exposed Playa.

The term "emissive" refers to a land surface's tendency to emit sufficient dust to cause or contribute to an air quality violation. "Non-emissive" is used to describe surfaces that do not emit sufficient dust to cause or contribute to air quality violations.

All restoration alternatives must contain Air Quality Management actions related to this four-step process. In coordination with landowners and stakeholders, access to Exposed Playa will be controlled to avoid disturbance and resulting emissions. In concert with the MMRP, a research program focusing on development of cost effective, water efficient, and adaptive Air Quality Management has been initiated and will continue. In the long run, results of this effort will guide the Air Quality Management approaches implemented at the Salton Sea.

Regional air quality management districts are responsible for identification and planning to address air quality problems, including issues such as particulate matter that might be emitted from the future playa. Approaches developed in this technical memorandum have been reviewed with these agencies and are generally consistent with air quality laws and ordinances, as well as the districts' planning processes. Plans have also been discussed with the California Air Resources Board and the U.S. Environmental

Protection Agency, and reviewed by technical specialists from the Desert Research Institute and by numerous and diverse stakeholders.

A range of dust control measures have been and will continue to be evaluated. Dust control measures requiring little or no water are preferred because of the high demand and resulting high cost for water in Southern California. Although many dust control measures are under consideration at this time, no similar area with high emissions rates has been stabilized without water. Water and capital requirements for Air Quality Management under the alternatives are therefore based on water efficient, but not necessarily water-free, dust control technology.

For the purposes of the PEIR, assumptions and contingencies were developed that form the basis of Air Quality Management for Exposed Playa under the alternatives. The approach represents a reasonable "worst-case" analysis, applied to all alternatives, including the No Action Alternative.

While a broad range of means for stabilizing Exposed Playa will be considered in future research and may ultimately be implemented, air quality regulatory agencies favor a placeholder (engineering analysis based on a specific technology) approach as part of the PEIR. To the extent possible, a placeholder technology should have been proven feasible and effective at a large scale. Sufficient resources for its implementation should be incorporated into the alternatives, along with contingencies. The approach also must achieve this goal as efficiently as possible.

In addition to placeholder technologies, this technical memorandum identifies a number of land stabilization and dust control approaches, representing a wide range of capital costs, operations and maintenance costs, and water requirements. Some approaches have been proven at a large scale, while others are in early stages of development. Many of the identified approaches, and many combinations of them, could be implemented within the resource allocations made for the placeholder technology.

Based on anticipated requirements and performance criteria, three temporary and three permanent Air Quality Management approaches are identified and developed in greater detail. If other more desirable technologies meeting the essential performance criteria are identified later, project-specific planning and implementation may incorporate these approaches, in lieu of the placeholder technologies employed in the alternatives. In this way, adequate resources and contingencies are reserved for the avoidance of air quality impacts of restoration alternatives, while allowing for incorporation of new knowledge.

Temporary approaches in the PEIR include sand fences (or other linear sand capture features, such as moat and row), surface treatment (with stabilizing agents), and control of traffic. These measures would be applied where permanent approaches are not feasible (e.g., areas that have not yet been sufficiently dewatered to allow for construction).

Permanent approaches in the PEIR include water efficient vegetation (likely salt- and drought-tolerant native shrubs and/or grasses), stabilization with brine (wetting and replenishment of salt on unstable surfaces to create a stable salt crust), and control of traffic. The permanent approaches used for planning would each require 1.2 feet of irrigation per year[1] or less. Water efficient vegetation may also require extensive subsurface drainage.

Table H3-1 summarizes the temporary and permanent dust control measures recommended for Air Quality Management, based on performance criteria.

[1] Depth of water applied annually, about 1 foot of which is inflow to Salton Sea.

Table H3-1
Select Dust Control Measures

Dust Control Measure	Basic Concept	Constraints, Requirements, Advantages, Effectiveness	Preliminary Finding for Large-Scale Implementation at Salton Sea
Temporary Dust Control Measures			
Surface Treatment (Chemical Treatment and Stabilization Products)	Increases adhesion between surface soil particles	• Unproven over large areas • Long term performance and environmental issues • Potential environmental issues (depends on material and environment) • Frequent re-application can lead to high cost	Potentially feasible for temporary control, especially for reduction in road/berm watering frequency.
Sand Fences	Capture mobile sand	• Requires periodic removal and disposal of trapped sand • Long term maintenance difficult and expensive	Potentially feasible for temporary control of small areas.
Control of Traffic	Restrict unwanted traffic from Exposed Playa	• Land ownership and jurisdictions must be respected and coordinated • Legitimate public access must be allowed • Large land areas involved • Large potential benefit at relatively low cost • Also applies to construction and operations traffic	Essential for large areas of playa; need to maintain necessary access while limiting playa disturbance.
Permanent Dust Control Measures			
Stabilization with brine	Spread brine to form stable salt crust	• Uncertain crust stability • Not proven effective • Attractive for areas flooded seasonally by brine pond • Outside the brine pond, would likely require an oversized system for highly emissive periods • May cause ponding that could mobilize selenium into the food chain for birds	Potentially feasible, especially for playa surface immediately adjacent to brine pond. Further research required to confirm effectiveness and to refine requirements.
Water efficient vegetation	Establish irrigated vegetative cover to reduce surface wind velocity	• Considerable infrastructure and operations effort required • Proven feasible and effective at Owens Lake • Water demand approx. 33 percent of seasonal surface wetting, 16 percent of open water	Proven dust control measure, but high capital and operations and maintenance costs; need to resolve performance specification issues and plan additional time for implementation.
Control of Traffic	See Control of Traffic, above, under Temporary Dust Control Measures		

The Next Steps considered in Chapter 10 could also include monitoring of Exposed Playa, as follows:

- Regional meteorological and aerometric monitoring;
- Intensive monitoring of newly exposed areas;
- Less intensive, long term monitoring of areas deemed “stable” (that is, minimally or non-emissive surface);
- Monitoring of Air Quality Management facilities’ compliance with dust control performance specifications (such as percent vegetative cover) and effectiveness in controlling potential dust sources; and
- Feedback of monitoring results into the Air Quality Management process to guide design and adaptive management of Air Quality Management facilities.

As a result of monitoring feedback and results of dust control research and development, Air Quality Management could be adaptively managed. For example:

- A smaller area than that assumed may require irrigation, either because larger areas of the playa are stable, or because more water efficient dust control measures (such as gravel blanket) prove effective and implementable. In this case, additional water, previously allocated for Air Quality Management, would be available for other purposes, such as habitat; and
- Additional water (in excess of assumptions in alternatives) may be required for Air Quality Management, if more water efficient measures prove ineffective or infeasible in some areas. In this case, supplementary environmental documentation for the allocation of this water supply would be required.

BACKGROUND AND PURPOSE

As part of the PEIR, air quality issues associated with the alternatives were identified and evaluated. Approaches to mitigation of potential impacts were identified, and control measures (to the extent feasible and practicable) were included in the alternatives. Air quality impacts of the alternatives, as described, were analyzed.

Exposure of lands in the Sea Bed may increase dust emissions from wind erosion. The extent, timing, and location of this exposure would vary widely among the alternatives. The types and amounts of emissions that could occur were evaluated, and monitoring and control measures for potential dust emissions are being identified. Taken together, this monitoring and control is referred to as Air Quality Management.

The goal of Air Quality Management is to provide to the maximum feasible elimination of air quality impacts from the restoration projects. To this end, a framework for evaluation of potential dust emissions from the Exposed Playa was developed. That assessment and efforts to map sediments to characterize their emissivity do not resolve uncertainty regarding the scale, location, timing, and magnitude of future dust emissions from the Exposed Playa. Therefore, this appendix identifies a monitoring and control approach to PM_{10} emissions for Exposed Playa Areas.

The approach to Air Quality Management on Exposed Playa is proactive. That is, expected emissions sources were identified and quantified in terms of extent and intensity. Specific dust control measures were identified and incorporated into alternatives. Long term approaches would be flexible and adaptive to accommodate new knowledge regarding the nature of the problem and cost effective solutions.

The planning framework for estimating Exposed Playa emissions distinguishes between two broad classes of playa. These classes and playa emissions control strategies can be summarized as follows:

1. **Playa on which a particular land use would be specified, such as agriculture or wetlands for wildlife habitat.**

   Emissions from these areas would be controlled by a wide range of strategies compatible with the associated land use. In the case of the wetlands, for example, roads might be graveled or watered, and berms vegetated. In any case, dust control measures would be incorporated into these land uses as part of their detailed description and implementation.

2. **Playa on which no specific land use is identified.**

   The main project features in these areas would be facilities and operations whose primary purpose is to control dust emissions. These playa areas and associated project features are termed Air Quality Management.

During the time period of preparation of the PEIR, the development and planning of Air Quality Management for the alternatives faced several challenges:

- Only limited amounts of Salton Sea playa have been exposed to date, and limited knowledge exists regarding future playa characteristics (e.g., playa composition, playa stability and emissions relationships and dynamics, and suitability for various types of land management, such as drainage and irrigation to grow plants);
- Existing emissions estimation models are not well adapted for playa conditions, where surface salts and subsurface hydrology strongly influence playa stability dynamics. While salt cementation may harden the playa and make it resistant to erosion, this resistance varies across the playa and over time;
- Playa stabilization literature is limited, and much of it was developed specifically for Owens Lake. Research required under the IID Water Conservation and Transfer Project MMRP (IID, 2003; SWRCB, 2002) on Salton Sea playa stabilization is in its early stages;
- Playa stabilization strategies applied on a large scale at Owens Lake require water and significant infrastructure and may pose significant new ecological risk if employed on the Salton Sea playa; and
- The Clean Air Act and related laws, ordinances, rules, and standards do not allow for a “wait and see” approach. Rather, alternatives must identify and address potential emissions sources with reasonable specificity, so that local air quality is not degraded as a result of restoration.

Three parallel processes were completed during preparation of the PEIR and are suggested to be considered for continuation during project-level analysis. These processes and related efforts are as follows:

1. **Refine understanding of future playa emissions patterns.**

   - Evaluate models used to simulate playa crust dynamics, emissions processes, emissions dispersion, and air quality impacts;
   - Develop the meteorological databases required to run these models;
   - Augment characterization and mapping of future playa materials and likely playa stability;
   - Perform wind tunnel testing on sites representative of future playa, where possible;

- Augment baseline meteorological and air quality monitoring;
- Plan meteorological and aerometric monitoring as part of alternatives; and
- Coordinate with stakeholders in implementing the first two steps of the four-step process defined for air quality mitigation under the IID Water Conservation and Transfer Project MMRP (i.e., restrict access, and conduct research and monitoring).

2. **Develop dust control plans for Air Quality Management areas based on existing knowledge, while developing other options.**
   - Establish dust control performance criteria appropriate to the PEIR and Salton Sea playa;
   - Review dust control literature, for example, any existing studies that are specific to the Salton Sea, as well as studies from Owens Lake, the Western Regional Air Partnership, and Clark County, Nevada;
   - Identify and develop conceptual Air Quality Management steps appropriate for inclusion in alternatives;
   - Define a feasible and reliable plan that includes proven technology and sufficient flexibility so that future refinements in knowledge of the Salton Sea playa and Air Quality Management methods can be incorporated to produce more efficient or effective Air Quality Management steps in the future; and
   - As part of the coordinated effort with research and development under the Next Steps, initiate research and development on efficient and effective means to control dust on the playa.
3. **Plan for feedback of new information and adaptive management during Next Steps.**
   - Identify knowledge gaps in Air Quality Management at the time of preparation of the PEIR;
   - Incorporate improved or different dust control approaches into project-specific plans and environmental documentation, after a restoration alternative is selected;
   - Monitor the emerging playa for emissions, and the implemented dust control for compliance and effectiveness;
   - Identify processes and schedule for feedback, plan refinement, and (after implementation) adaptive management; and
   - Further refine dust control measures, as monitoring data indicate.

OVERALL APPROACH TO PLAYA STABILITY AND DUST CONTROL IN THE PEIR

To provide adequate assurance that air quality would be protected under the alternatives, uncertainties would be balanced with the best available technologies and conservative delineation of potentially emissive areas. Several examples of conservative assumptions made in the PEIR include the following:

1. The planning model for the Salton Sea playa was, in many respects, the Owens Lake playa. However, Owens Lake playa is a worst-case scenario for emissions rates from an Exposed Playa. Owens Lake emissions are considered to result from an unusual combination of climatic, geochemical, and watershed conditions, a number of which would not be replicated at Salton Sea.

2. Even at Owens Lake, most of the Exposed Playa does not require active dust control to demonstrate attainment with State and federal ambient air quality standards; rather, 29.8 of about 89 square miles of Exposed Playa have been designated as requiring control, and an additional 8.7 square miles are currently under consideration. At Salton Sea, emissive areas cannot be distinguished from non-emissive areas during this planning period because the playa is still covered with water. It is assumed that nearly all exposed areas would be either: (a) used for and stabilized by another land use, or (b) designated to receive Air Quality Management. Air Quality Management could take the form of either long term monitoring (for stable areas) or dust control (for areas that require it).

3. At Owens Lake, areas intermittently covered by the brine pool have not been included among areas requiring stabilization. This is due to a combination of their periodic wetness, stabilization by salt when not flooded, and distance of these low-lying areas from potential receptors. At Salton Sea, the approach documented here assumes active Air Quality Management would potentially be needed in areas intermittently exposed by a fluctuating brine pool.

4. Preliminary information based on Salton Sea area wind speed and temperature-humidity regimes indicates that the Salton Sea playa are expected to be less emissive than the Owens Lake playa. Although these conditions will be considered during impacts analysis, the approach assumes that exposed areas would be potentially emissive, and, therefore, dust control would be incorporated into restoration alternatives for exposed areas.

This conservatism is, in turn, balanced by adaptive management strategies, which are built into planning and design approaches. During the extended planning and implementation period, much would be learned, and current uncertainties should be significantly reduced. This would allow for refinement of the conservative approaches presented in this document. In this way, initial Air Quality Management plans can be modified to meet goals as efficiently as possible by focusing resources where they would provide the most benefit.

A conservative or worst case approach is favored by air quality agencies in their planning processes. However, a judgment must be developed based on best available scientific and engineering knowledge when planning use of resources and infrastructure for Air Quality Management. This apparent conflict is resolved by the inclusion of contingencies that allow for successful implementation of the project, even if the worst case ensues. Therefore, for infrastructure and water balance planning in the PEIR, the following assumptions and contingencies form the basis of Air Quality Management for Exposed Playa:

- A monitoring program would be established to determine emissivity of the playa as water recedes;
- The Exposed Playa would be protected from disturbance as water recedes;
- Alternative land uses that stabilize Exposed Playa and are otherwise feasible and acceptable (e.g., farming by landowner, or development of natural vegetation) would reduce the area where Air Quality Management by other means would be necessary;
- Based on experience in similar environments, it is expected that a substantial portion of Exposed Playa would not be emissive and would be transitioned to long term monitoring. If monitoring later determines that an area has become emissive, it would be subject to control measures;
- Portions of the Exposed Playa would be emissive, and these emissive conditions may be seasonal;
- Emissive areas would be stabilized by one or more methods, such as water efficient vegetation, surface wetting, or gravel cover. A variety of dust control measures would remain available. A range of dust control measures has been and would continue to be evaluated, until significant questions regarding dust control on Salton Sea playa have been resolved. dust control measures

requiring little or no water would be preferred because of the many competing needs for water. No options would be eliminated from consideration unless proven infeasible or ineffective. Implemented dust control measures would be monitored for their effectiveness and adaptively managed;

- Irrigated, water efficient vegetation is considered as a placeholder technology in the PEIR;
- If control is needed, water-based dust control measures, such as water efficient vegetation, would be implemented on up to 50 percent of the Exposed Playa Area. The Exposed Playa Area is defined as the area exposed above the high water level of the Brine Sink at its lowest elevation in Phase IV;
- Other Exposed Playa would be either non-emissive or controlled by other means. For the purposes of the PEIR, it has been assumed that 30 percent of the Exposed Playa under each alternative would be non-emissive. If emissive, dust from the remaining Exposed Playa would be controlled by other dust control measures, such as stabilization with brine, chemical stabilization, or gravel;
- Inflow water would be allocated for potential Air Quality Management needs. For the purposes of the PEIR, about 1 foot per year (1 acre-foot per acre per year) of inflow water would be allocated for 50 percent of the Exposed Playa under each alternative;
- If allocated resources prove to be in excess of actual Air Quality Management needs, water would be re-allocated to other uses (e.g., habitat);
- If more inflow water is needed, or more than 50 percent of the Exposed Playa proves emissive, the dust control measure would be planned in coordination with air quality regulatory agencies. The PEIR assumes stabilization with brine, application of chemical dust palliatives for dust control, or some other method that does not require inflow water for all alternatives with Air Quality Management; and
- If additional resources are required for Air Quality Management, supplemental environmental documentation would likely be required.

This approach is considered representative of a reasonable worst-case analysis, applied to all alternatives, including the No Action Alternative. This conservative approach is intended to:

1. Manage risk;
2. Allow for adaptive management; and
3. Provide an analysis of the reasonable worst case with regard to emissions, water availability, and water demands.

EVALUATION OF TECHNICAL OPTIONS FOR PLAYA DUST CONTROL MEASURE DEVELOPMENT

Technical options for playa dust control measures have been evaluated, by considering the potential future requirements for control, establishing criteria for performance of control measures, and prioritizing options that show potential for meeting the established performance criteria at the Salton Sea. Options recommended at this time are primarily for planning ecosystem restoration resource allocation for Air Quality Management. Final determination of technical approaches to dust control will occur at the project planning level, at which time site-specific research, monitoring, and pilot testing will provide additional information regarding the effectiveness and resource requirements of options. To meet resource planning needs, recommended options for both temporary and permanent Air Quality Management are described in greater detail in later sections of the document.

Requirements for Dust Control – Where and When Playa Dust Control May Be Required

Figure H3-1 illustrates the flow of decisions relative to implementation and type of Air Quality Management. As restoration proceeds, the pattern of wet areas and land use on dry areas would shift and evolve. For an alternative, a combination of land use, bathymetry, inflows and flow routing, and water balance would dictate the footprints of drained or flooded areas at any given time. As described above, areas exposed in an alternative and not planned for a defined land use (such as habitat restoration, geothermal energy development, or agriculture) would be designated as Air Quality Management areas. Air Quality Management includes monitoring, surface protection, and if needed, dust control.

All Air Quality Management areas will be monitored and, to the extent feasible, protected from traffic that might damage the fragile playa surface and make it more emissive. The goals of monitoring are to:

- Improve our understanding of when and where emissions occur on the Exposed Playa;
- Focus dust control efforts on the most important emissive areas of the playa; and
- Improve the effectiveness and efficiency of dust control measures.

Monitoring would take one of two forms: short term and long term monitoring. Short term monitoring is the most intensive and focused on collecting information to determine if an emissive area requires immediate dust control. Long term monitoring is less intense and designed to verify that Exposed Playa areas are *stable*, that is, non-emissive. Emissive areas that have undergone dust control will be transitioned from short to long term monitoring as the dust control measures take effect and stabilize the playa surface against the effects of wind erosion.

Criteria for determining which areas of the playa require dust control include the following:

1. Alternatives should achieve requirements for consistency and conformity with applicable laws and regulations;

2. Air Quality Management and dust control (if indicated) would be phased in as new playa areas are exposed; and

3. Dust control would be implemented on emissive areas of Exposed Playa (as determined by monitoring).

Dust control areas would contain facilities whose primary purpose would be surface stabilization and dust control. Timing of implementation would vary, depending on patterns and rates of playa exposure or dewatering, and the emissivity of the exposed area. Permanent dust control would be implemented in constructible areas on emissive areas. Constructible areas of Air Quality Management would be of a size and shape that would facilitate construction of facilities.

In general, dust control would be implemented in areas permanently exposed (or dewatered), that is, where inundation of surface and saturation of the subsurface is no longer foreseen, except possibly during infrequent flood events. Controlling emissions would follow the following logic, as summarized in Figure H3-1:

- If playa is moist, it should produce little dust and should not require construction of dust control. As constructible areas are exposed or dewatered, emissions and air quality would be monitored;

- Where monitoring indicates that an area (with or without existing dust control) chronically emits at rates that threaten air quality, new or improved dust control would be implemented to remedy the problem;
- Where dust control is needed before permanent facilities can be constructed, temporary dust control would be implemented along with long term monitoring for effectiveness;
- Constructible areas that need dust control would be designated for construction of permanent dust control facilities and long term monitoring for effectiveness; and
- Where changing an implemented dust control measure can be shown to be equally effective at lower cost or water demand, dust control facilities can be adapted to reflect this new information.

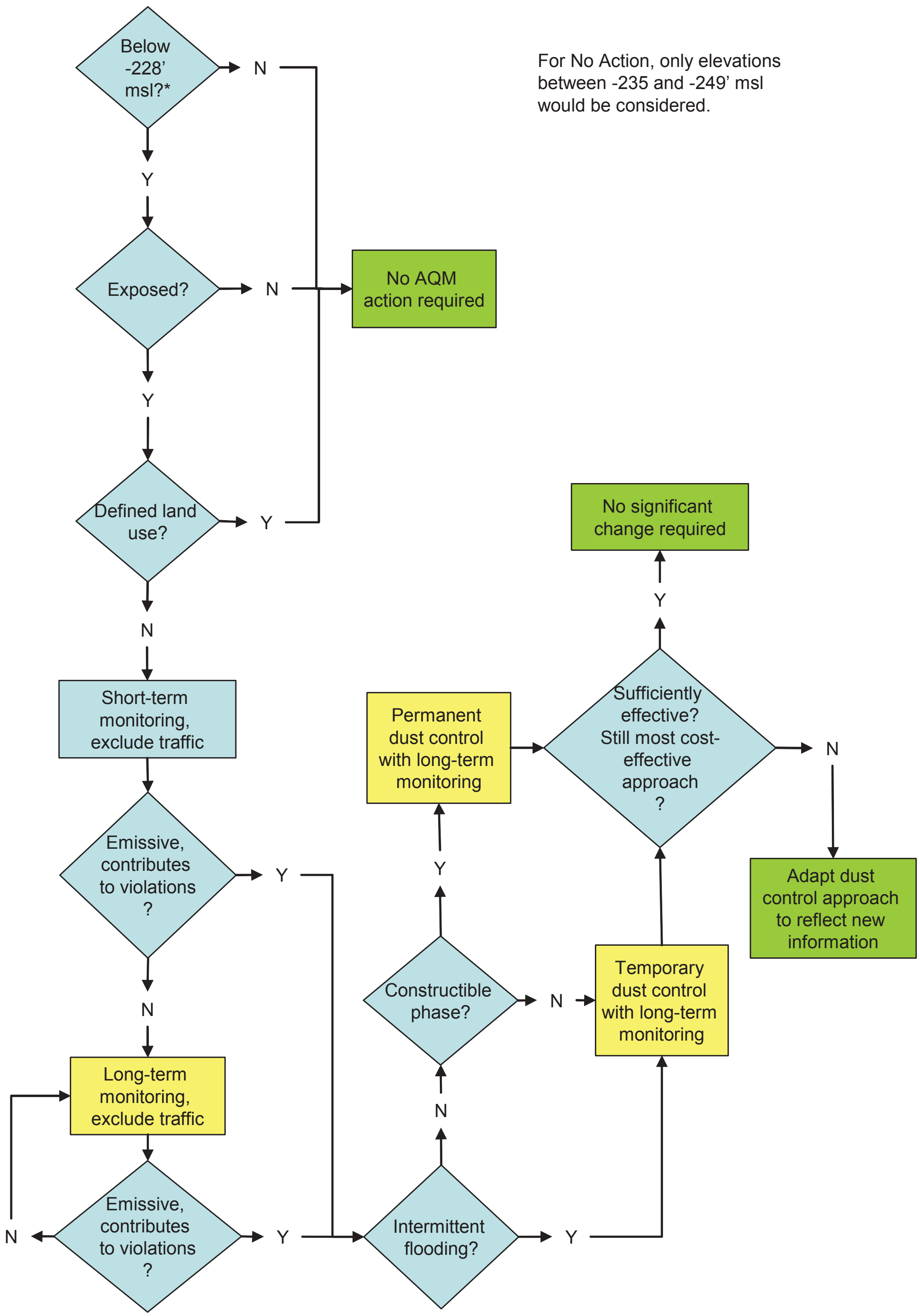
Dust control would be designed based on the best available knowledge at the time of the design. Construction would itself cause emissions, both directly from equipment and during ground disturbance, and after actual construction during startup, before the disturbed area becomes stabilized. Construction emissions have been considered in a separate analysis. Elevated emissions during startup are difficult to estimate, but would be eliminated as dust control becomes effective. The length of the initial, unstable period depends on the means selected for control.

Performance Criteria for Surface Stabilization and Dust Control

To support the requirements for Air Quality Management under the alternatives, performance criteria have been established for evaluation of options for surface stabilization and dust control for exposed areas at the Salton Sea. Dust control measures must meet the following criteria:

1. **Effective and reliable**

- The alternative should provide adequate resources to support implementation of dust control measures that have been proven effective for control of extensive Exposed Playa Areas. dust control measures must be reliable in limiting dust emissions from the surface in question to very low levels, even while allowing for development of the most efficient and cost-effective dust control approaches that can reliably stabilize the emerging playa. As viable, less costly alternatives are sought and proven to be effective on this specific site, they should replace more costly approaches in the planning and implementation processes. Outdated approaches may be replaced where this is cost-effective;
- Facilities must be designed, constructed, and operated in a timely manner to avoid prolonged periods during which air quality would be significantly degraded by large areas of emissive playa;
- Long term effectiveness should be flexible in responding to substantial environmental changes (e.g., drought, flood, fire, frost, plant pathogens, anticipated playa surface and subsurface drainage, and shallow groundwater quality);
- Effectiveness of dust control approaches must have been confirmed during applicable research and development, then monitored to verify effectiveness of implemented dust control; and
- Based on monitoring data, dust control would be adapted over time to achieve goals.



For No Action, only elevations between -235 and -249' msl would be considered.

FIGURE H3-1
LOGICAL FLOW OF AQM DECISIONS FOR PLAYA AREAS

2. **Feasible and cost-effective**
   - Implementation should be phased with creation of newly Exposed Playa Areas (constructible areas);
   - Design should be proven from the standpoint of constructability and operability;
   - Design should be flexible for adaptive management;
   - Water supply, capital, and operations and maintenance requirements should be as efficient as practicable to achieve adequate air quality;
   - If water is required for dust control, then water supply, quality, quantity, and timing should be defined and allocated in the alternative;
   - If a vegetative approach is planned, an adequate supply of planting material must be developed or available for purchase; and
   - Dust control design, construction, and operations and maintenance in each phase should build on the foundation of research, development, and experience during previous phases.
3. **Consistent with other features and objectives**
   - Measures should avoid creation of significant human health and eco-toxicity risks;
   - Water quality should not be significantly degraded;
   - Habitat benefits should be generated where feasible and not in conflict with the core Air Quality Management function;
   - If more water efficient means of dust control are developed, proven, and planned, surplus water previously allocated for dust control would be released for other uses, according to restoration objectives and applicable laws; and
   - If additional water is required due to unforeseen demand (larger control areas or less water efficient control), additional water would need to be allocated.

Preliminary Prioritization of Options for Playa Dust Control

A range of options have been considered for controlling dust emissions from Exposed Playa. Much of the existing literature on playa dust emissions control has been developed in association with the Owens Lake Dust Control Program. This section summarizes the range of potential dust control measures. For each dust control measure, the applicability and basic suitability of the measure for use in the alternatives is presented, based on the established performance criteria.

Table H3-2 summarizes potential dust control measures, suitability considerations, and preliminary findings for large-scale implementation at Salton Sea. Because of the significance of water requirements in evaluating suitability, the dust control measures are divided into two categories: those that would require significant water as a major operational feature, and those that would not require a significant ongoing water supply.

A subset of dust control measures has been identified as potentially suitable for application in the Salton Sea PEIR. These dust control measures are described in more detail in the following sections. Dust control measures requiring water are described first, followed by those with minimal water requirements. For each dust control measure, the principle of operations is described, followed by comments on the dust control measure's suitability, and recommendations for application at the Salton Sea. Recommended options are then described in more detail, for both temporary and permanent dust control.

Table H3-2
Preliminary Prioritization of Dust Control Measures

Dust Control Measure	Basic Concept	Constraints, Requirements, Advantages, Effectiveness	Preliminary Finding for Large-scale Implementation at Salton Sea
Require Water			
Stabilization with brine	Spread brine to form stable salt crust	• Uncertain crust stability • Not proven effective • Attractive for areas flooded seasonally by brine pond • Outside the brine pond, would likely require an oversized system for highly emissive periods • May cause ponding that could mobilize selenium into the food chain for birds	Potentially feasible, especially for playa surface immediately adjacent to brine pond. Further research required to confirm effectiveness and to refine requirements.
Water efficient vegetation	Establish irrigated vegetative cover to reduce surface wind velocity	• Considerable infrastructure and operations effort required • Proven feasible and effective at Owens Lake • Water demand approx. 33 percent of seasonal surface wetting, 16 percent of open water	Proven dust control measure, but high capital and operations and maintenance costs; need to resolve performance specification issues and plan additional time for implementation
Seasonal Surface Wetting	Wet soil surface during dust season	• High water demand • Proven feasible and effective at Owens Lake playa • May cause ponding that could mobilize selenium into the food chain for birds	Not considered further in this study due to high water demand.
Regular Water Spreading	Periodic moistening with intervening drying of surface	• Suitable for areas that need to be maintained free of vegetation and emissions, such as roadways • May not be reliable on larger playa areas • Considerable distribution facilities or trucking effort required	Suitable for facilities such as roadways and berms.
Event-driven Irrigation	Wet soil quickly when needed	• Uncertainty in scheduling irrigation to prevent wind erosion • Oversized facilities required unless lead time is provided by improved event prediction • High-pressure head requirements likely to move water quickly over large areas • Most problematic during high winds, when needed	Not considered further in this study. Further research required to confirm effectiveness and to refine technical approach.

Table H3-2
Preliminary Prioritization of Dust Control Measures

Dust Control Measure	Basic Concept	Constraints, Requirements, Advantages, Effectiveness	Preliminary Finding for Large-scale Implementation at Salton Sea
Minimal Water Required			
Control of Traffic	Restrict unwanted traffic from Exposed Playa	• Land ownership and jurisdictions must be respected and coordinated • Legitimate public access must be allowed • Large land areas involved • Large potential benefit at relatively low cost • Also applies to construction and operations traffic	Essential for large areas of playa; need to maintain necessary access while limiting playa disturbance.
Moat and Row	Capture mobile sand in moats, break wind with row	• Anecdotal observations that this has been effective at Owens Lake • Moat maintenance (periodic cleanout or new moats required)	High potential for widespread, cost-effective sand suppression; control efficiency probably moderate. Further research required to confirm effectiveness and to refine approaches.
Gravel Cover	Cover emissive soil with gravel	• Unproven over large areas • Gravel supply, transportation, placement, and settlement issues unresolved • Needs perimeter protection to avoid infilling • May require underlying geotextile	Not considered further for large areas of playa in this study. Possible application for small areas.
Chemical Treatment and Stabilization Products	Increases adhesion between surface soil particles	• Unproven over large areas • Long term performance and environmental issues • Potential environmental issues (depends on material and environment) • Frequent re-application can lead to high cost	Not currently considered further for large areas of playa in this study due to high maintenance cost. Potentially feasible for temporary control, especially for reduction in road/berm watering frequency.
Tillage	Roughen surface with heavy, primary tillage, capture sand	• Temporary, must be repeated • Increases emissions periodically (during actual tillage)	Not currently considered in this study due to elevated emissions during construction and relatively frequent maintenance.
Sand Fences	Capture mobile sand	• Requires periodic removal and disposal of trapped sand • Long term maintenance difficult and expensive	Not suitable for permanent control. Potentially feasible for temporary control of small areas.

Dust Control Measures That Require Water

The dust control measures presented in this section require ongoing delivery of significant volumes of water as part of their primary operational nature. These dust control measures include the following:

- Stabilization with brine;
- Water efficient vegetation;
- Seasonal surface wetting;
- Regular watering; and
- Event-driven irrigation.

Stabilization with Brine (Enhanced Salt Crust)

Principle of Operations

Stabilization with brine to control dust involves spreading salt water over the ground surface, allowing subsequent evaporation of the water, thus creating a heavy salt crust. This process may be thought of as enhancing natural salt crust formation processes. This dust control measure would create a heavy salt crust from minerals naturally present in the brine of the resident waters of the Salton Sea. This enhanced salt crust would act as a protective cover over the sediments that would minimize surface erosion and entrainment of particulate matter from the soil surface (as long as it remains stable). Natural formation of stable surface crusts is an important natural control mechanism of particulate emissions from playas throughout the western U.S. When the salt crusts remain stable, control efficiencies approaching 100 percent are common. However, when playa crusts degrade in an area because of climatic fluctuations, leaching of salts by water, or erosion by wind or water, they may cease to provide adequate protection. Under these circumstances, restoring the stable crust in the vulnerable area may be necessary to retain acceptably low rates of emissions during high wind events.

Stabilization with brine could be accomplished through any method that spreads salt water across most of the playa surface. Application could be achieved in low-pressure, surface irrigation systems, or through higher pressure sprinkler irrigation systems.

A variant of this approach has been proposed. This involves the construction and operation of salt ponds that would be managed to concentrate and precipitate primarily sodium chloride, which is resistant to erosion. In one alternative, this approach is assumed to be the predominant dust control measure. It is not exclusively considered, nor is it excluded, from dust control approaches that might be implemented under other alternatives.

Suitability

Salt crusts are a common feature of saline playas, but depend on the site-specific salt mineral chemistry, depth to shallow groundwater, surface hydrology, and weather conditions. Often when temperature is low and relative humidity high, certain salts (e.g., sulfates of sodium) soften and become unstable. Disturbance of the crust by natural forces or human activities can break and destabilize crusts. In either case, the natural stability of an area, or the effectiveness of the crust as a dust control measure, can be compromised. Salt crust stability and dynamics are discussed in more detail later in this document and in other reports (DWR, 2005a; and Great Basin Unified Air Pollution Control District [GBUAPCD], 1996, 1997). More information is needed to assess the effectiveness of this approach for control of playa emissions at the Salton Sea.

If surface irrigation is used, there is potential for ponding (i.e., standing water) to occur in low spots. If ponding persists for substantial periods of time, aquatic invertebrate populations may increase, creating an attraction for birds. Sediments or applied water rich in selenium could provide a mechanism for introduction of selenium into the food chain and affect sensitive bird species.

The use of sprinkler irrigation could minimize ponding and reduce the likelihood of these undesirable conditions. Regardless of irrigation method, where water is of sufficient salinity (>100,000 milligrams per liter [mg/L] salinity), development of a viable food chain is unlikely. This greatly reduces the risk of ecological toxicity related to this dust control measure.

Recommendations

Preliminary information suggests that salt mineralogy at the Salton Sea could result in unstable crusts during some weather conditions. The concept of stabilization with brine has not been proven on a large scale under conditions similar to those present at the Salton Sea. However, the possible effectiveness and water-saving potential of this dust control measure warrants further investigation. Therefore, this dust control measure should be developed and tested, particularly for implementation near the fluctuating brine pond. This will provide the experience necessary to assess potential performance. This testing is essential before widespread application.

Where this dust control measure is used, ponding must be minimized to avoid to concomitant effects on bird populations. A relatively saline (> 100,000 mg/L salinity) brine could be applied to minimize food-chain development and ecotoxicity risks to bird populations.

Water Efficient Vegetation

Principle of Operations

Vegetative cover controls dust by reducing wind speeds at the soil/air interface by trapping moving soil particles and by anchoring the soils with roots. Vegetation naturally reduces windblown dust in much of the western United States. On salt playas, however, high salt content and poor natural drainage in the soil often prevent natural development of vegetative cover. Furthermore, in arid and semi-arid areas, natural precipitation may be inadequate to support vegetative cover of sufficient density or character to adequately suppress wind erosion and entrainment of dust particles.

By providing additional water of appropriate quality, providing artificial drainage where necessary, and planting salt-tolerant vegetation, plant cover can be established in locations where natural vegetation is absent or insufficient to control dust.

Once established, vegetation has been shown to be effective in controlling wind-driven sand motion and associated dust emissions. Vegetation has been applied for this purpose on Owens Lake playa, and sand motion has been monitored. Figure H3-2 shows sand motion monitoring results from the local air district and the Los Angeles Department of Water and Power (LADWP) over time, relative to the pattern of vegetation development. Little sand motion was observed after the site achieved about 10 percent cover. Because sand motion is the driving force behind most dust emissions, this result indicates effective control.

Suitability

Irrigated vegetation has been successfully implemented in conditions with similar salinity and terrain as those expected on exposed portions of the Salton Sea playa. Specifically, more than 3 square miles of irrigated native saltgrass have been established on salt playa at Owens Lake, and early monitoring has shown the measure, called “managed vegetation” in Owens Lake literature, to be highly effective at controlling particulate emissions. Figure H3-2 shows sand motion data and cover development over time, indicating that significant sand motion ceased after the saltgrass vegetation was established in 2003.

Vegetation is a water efficient means of controlling dust. It requires about 20 to 30 percent of the water depth required by measures that rely on prolonged surface wetting for control.

Recommendations

While soil and climatic conditions at Salton Sea are somewhat different from those encountered at Owens Lake playa, no critical obstacles to establishment of irrigated vegetation at Salton Sea have been identified. The water requirement for irrigated vegetation is considerable, but through appropriate selection of plant species and planting density, the water demand would be expected to be much less than that for most of the other water-based dust control measures described below. Considerable infrastructure is required to support reliable development of irrigated vegetation on the playa, including water conveyance, irrigation, and possibly subsurface drainage facilities. Despite these infrastructure requirements, this dust control measure has proven itself on another desert playa. Unless reliable measures with other desirable features (e.g., lower capital requirements and equivalent or lower water demands) are available, water efficient vegetation may serve as a control measure when planning air quality resource allocation.

A variety of irrigation and drainage technology could be employed to grow vegetation on the playa, depending on site-specific conditions and performance requirements (vegetation density, rate of establishment, species) for dust control. For planning purposes, vegetation has been considered to require technology that has worked well on the Owens Lake site, a relatively costly and sophisticated combination of subsurface drip irrigation and subsurface drainage. However, other systems may prove to work well, particularly on the better drained areas. A relatively low-tech, less costly approach that will be pilot tested is described in Attachment H3-1. Notably, the reclamation approach requires construction in the wet (reducing construction dust), and occasional surface irrigation would be applied. Clearly, where such approaches are effective and do not present other significant difficulties, they need to be considered by planners and designers.

Seasonal Surface Wetting

Principle of Operations

Seasonal surface wetting involves wetting the soil surface to increase inter-particle cohesion, thereby preventing dislodging and entrainment of dust particles during wind events. The measure is only required to be operational seasonally during periods when wind speeds and soil crust conditions are conducive to wind erosion and dust emissions. This dust control measure, termed “shallow flooding” at Owens Lake, has been applied successfully on more than 15 square miles of the Owens Lake playa. As practiced there, water is applied through a system of surface outlets along supply lateral piping to raise the groundwater level to near the surface and to maintain consistent wetting across large areas (See Figure H3-3).

Seasonal surface wetting, as practiced at Owens Lake, results in sustained wetting of 75 percent of the land surface in every square mile over the entire dust-prone season. This has two outcomes of particular note with respect to Salton Sea playa. First, between 4 and 5 feet of water are required per year[2] (for a 10-month dust-prone season, September through June at Owens Lake). Second, the wet or ponded areas attract shorebirds and waterfowl into the facility to forage and reproduce.

As with the irrigated vegetation measure discussed above, considerable infrastructure and facilities, including conveyance piping and containment berms, would be required to support seasonal surface wetting at Salton Sea. The Owens Lake system is designed to wet the area slowly and maintain that wetness seasonally (about 10 months per year). This minimizes the required size of conveyance facilities (because water can be applied gradually and application rotated around the site), and reduces the distribution facility density on the playa.

[2] Depth of water applied annually.

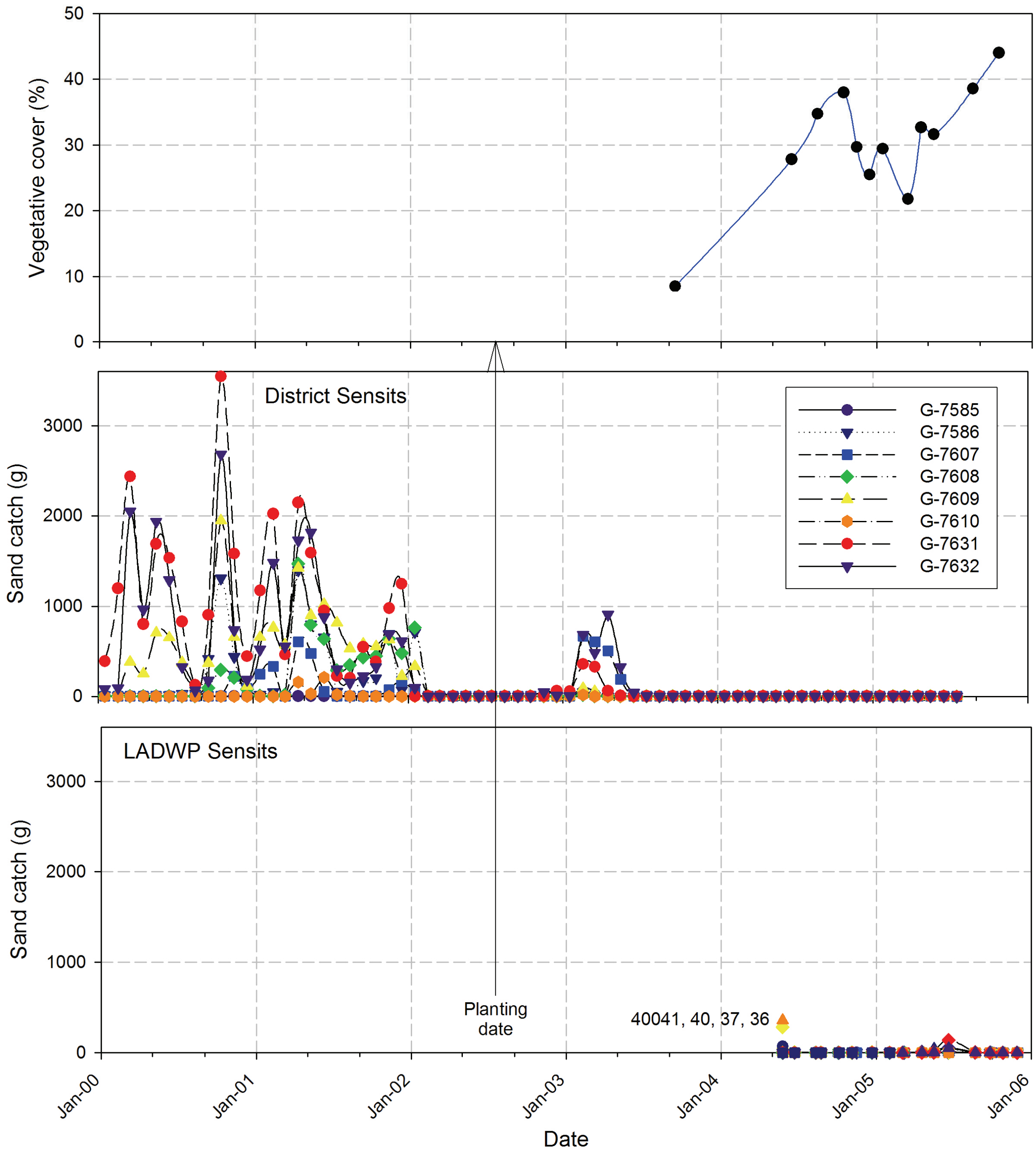


FIGURE H3-2
SAND MOTION AND VEGETATIVE COVER IN OWENS LAKE MANAGED VEGETATION
With the exception of the replanting period during spring 2004, there was no significant sand motion on the site after 2003. This suggests that sand motion can be arrested by fairly low (> 10 percent) levels of cover.

FIGURE H3-3
PHOTO OF SHALLOW FLOODING DUST CONTROL MEASURE AT OWENS LAKE

Suitability

The elevated water demand for water spreading renders this dust control measure unsuitable at the Salton Sea.

Implementation of this dust control measure on the Salton Sea playa would result in ponding in low spots. These ponds would persist for substantial periods of time. As already described, this ponding could support aquatic invertebrate colonization, which could, in turn, create conditions that would be attractive to birds. Such a situation could be a viable mechanism for undesirable introduction of selenium into the food chain.

Recommendations

Seasonal surface wetting as a dust control measure is not considered suitable for widespread application, given current information. This recommendation is based on the high water demand of this dust control measure relative to other options (about 3 to 5 times the water requirement for water efficient vegetation, for example), combined with the severe water supply limitations at the Salton Sea. In addition, the possibility of mobilizing selenium into the food chain for birds would be a significant concern.

Regular Watering

Principle of Operations

For areas that cannot or need not be saturated to reduce dust emissions, but where periodic wetting is effective, water would be applied (e.g., by water truck) at regular or climatically determined intervals. An example of such an area is a roadway, which can be wetted but not saturated, because it must bear traffic.

Suitability

This measure is likely suitable for any areas where it is practical to provide water at regular intervals, through either irrigation systems or water trucks. If applied in a manner that minimizes prolonged ponding of water below 100,000 mg/L TDS, this dust control measure would minimize the potential for food-chain development and associated ecotoxological risk.

Recommendations

It might be determined that periodic wetting, with intervening periods of drying, is effective in controlling dust on certain areas of the Salton Sea playa. Should the potential for reliable dust control by this means be demonstrated through research at a later date, it may be quite cost effective. In any case, this dust control measure will likely be employed on roads, berms, and construction areas where it is typically one of the most practical approaches to minimizing dust emissions.

Event-driven Watering

Principle of Operations

Event-driven irrigation controls dust through the same mechanism as seasonal surface wetting except that the surface is wetted only when monitoring of meteorological conditions (e.g., wind, relative humidity, and temperature) suggests that a potential emissions event is possible. Accordingly, successful implementation of this dust control measure requires that conditions leading to emissive events be well understood and predictable, and that an appropriate companion monitoring plan be implemented and properly interpreted. This approach would require the following:

1. A climatic model that would reliably predict emissive conditions with about a week’s notice.
2. A water supply (likely Salton Sea water) capable of high, intermittent, unscheduled, peak flows.
3. Conveyance and distribution facilities sized and pressurized to wet 30 to 50 percent of the exposed area with a week’s notice. On a unit area basis, these might be substantially larger and more costly per-unit irrigated area than those constructed at Owens Lake.
4. Drainage recapture and disposal facilities.

Suitability

Through application only at selective times, the extreme water demand of seasonal wetting is moderated. Implementation of this measure assumes that playa would be stable outside of clearly defined climatic ranges. As described above, this condition has not been adequately demonstrated. Further, the method pre-supposes a reliable model relating monitored climatic conditions to dust emissions events; unfortunately, this model has yet to be developed. Therefore, this concept is best adapted for responding to triggering based on more gradual changes affecting emissions potential (e.g., temperature and relative humidity changes that soften the salts that otherwise armor the playa surface), as opposed to triggering based on sudden changes (e.g., rising wind speeds).

Another key issue in implementing climatic event-driven surface wetting would be response time. Surface wetting facilities become much more costly as the response time shortens. Because water must be distributed over a large area more quickly, conveyance and distribution facilities need to be larger than for seasonal surface wetting.

Should the required wetting periods prove to be prolonged or frequent, there is potential for high water use by this type of system. This could occur either as a result of prevailing weather patterns, or because of conservative operations adopted to cope with inadequate or unreliable prediction tools.

This dust control measure has not been proven on a large scale. Because it would require only short-term wetting of the surface, ponding of water and the associated mobilizing of selenium into the food chain for birds may not be a major consideration.

Recommendations

As an unproven technology, event-driven irrigation is not included in the PEIR. As the technology is further investigated, issues to be resolved include the uncertainty associated with the development of an adequate monitoring and event prediction plan, the relative size and complexity of infrastructure required, and the potential for food-chain problems. However, the possible effectiveness and water-saving potential of this dust control measure warrants further investigation, and further research on its implementation and performance is recommended.

Dust Control Measures with Minimal Water Requirements

Dust control measures requiring minimal water include the following:

- Restricted access;
- Moat and row;
- Gravel cover;
- Chemical treatment and stabilization products (surface treatment);
- Tillage; and
- Sand fences.

These dust control measures are discussed in the following sections.

Restricted Access

Principle of Operations

Playa stability is often degraded by traffic, whether that traffic is wheeled, tracked, or foot. Therefore, the first step of the air quality mitigation under the 2003 IID Water Conservation and Transfer Project MMRP is the restriction of access to Exposed Playa Areas as a means of controlling traffic.

Playa stability has been extensively discussed (DWR, 2005a). This stability, or resistance to wind erosion, depends on the condition of the playa surface crust. Crusts result from cohesion of sedimentary particles upon drying, often with the aid of solid salt that forms as the crust dries. However, even a crust that is resistant to erosion may be pulverized by traffic, and once the crust has been broken, the soft surface beneath can produce dust at a much higher rate than the undisturbed, crusted surface.

By protecting crust from disturbance and destruction, stable crusts are left in place, where they provide one of the most effective means of natural dust control.

Suitability

There is extensive proof that land disturbance generally exacerbates wind erosion, so prevention of land disturbance is sure to be effective. However, the level of effectiveness may not be sufficient during the most emissive periods, so other measures may also be required where traffic is restricted.

While not often identified as a dust control measure, this approach could provide the most cost-effective control of dust emissions on the Salton Sea playa. This is particularly true given the frequency and intensity of off-road activity in the area. It could also help protect other dust control measures used in Air Quality Management and other facilities. Compatibility with desirable public and other legitimate access and use could be built into this dust control measure. Designated roads and trails are easier to navigate and less expensive to stabilize than multiple tracks spread across large areas.

Recommendations

This dust control measure should be retained because it is well suited to Salton Sea playa. Planning should be coordinated with the four-step process for air quality mitigation under the 2003 IID Water Conservation and Transfer Project MMRP and with large land owners in the area.

Moat and Row

Principle of Operations

At intervals across the playa, moats (or ditches) are excavated, with spoil (i.e., material excavated from the moat) placed alongside to form the row. On playas, windblown sand drives most dust emissions. This measure reduces emissions by interrupting sand flux across the playa surface through capture in moats, and by reducing surface wind velocity downwind of an adjacent row.

Suitability

This method has functioned reasonably well at Owens Lake, but its large-scale effectiveness and reliability are unproven. This dust control measure is more cumbersome to construct than a sand fence, but the basic function is similar, yet the sand capture capacity may be substantially greater. Like other sand capture approaches, once full, it is much less effective, and can become a problematic sand source unless capped in some manner. Therefore, maintenance is required, in the form of construction of new moat-and-row facilities, or the stabilization of facilities that have filled in so that they do not themselves become significant sand sources.

Recommendations

Moat and row facilities, which are relatively simple (involving mainly excavation) merit trial as part of the research. They could also be pilot tested (and monitored for effectiveness) relatively easily as areas become exposed. Options for combination with other dust control approaches could be considered. Because moat and row has not yet been proven effective on a large scale, it is not a suitable technology on which to base resource allocation for dust control.

Gravel Cover

Principle of Operations

A gravel cover dust control measure involves covering the finer soil material of the playa surface with a layer of gravel. Gravel cover prevents particulate emissions by physically protecting finer material beneath a bed of coarse material that is resistant to movement by high wind. It has also been observed that the presence of a gravel suppresses formation of evaporite salt crusts and associated efflorescence

(GBUAPCD, 1998). Construction of gravel cover on recently Exposed Playa soils may require an underlying geotextile to prevent gravel from settling into the soft soils.

Suitability

Gravel cover has been shown to control particulate emissions from small areas and along road surfaces. Covering significant areas with a 3- or 4-inch gravel layer, however, requires extremely large volumes of gravel. Even a 2-inch layer of gravel represents more than 170,000 cubic yards per square mile (230,000 tons/square mile). Quarrying, transporting, and placing this volume of gravel presents considerable supply and logistics difficulties and is costly. Further, fuel combustion in the equipment used to quarry, transport, and place these materials would result in a considerable amount of air contaminant emissions in the area.

This control method has been investigated and adopted in the Owens Valley Planning Area PM_{10} State Implementation Plan (GBUAPCD, 2003). GBUAPCD requires a 4-inch-thick layer of gravel for reliable control of emissions and evaporite salt crust prevention at Owens Lake (GBUAPCD, 1998). However, gravel has not been applied as a control measure on a large playa area at Owens Lake. The reasons for this include:

1. Mining and transportation of the required quantities of gravel are anticipated to be costly and would involve environmental impacts and significant permitting challenges;
2. Placement of gravel on large areas of playa, where bearing capacity can be low, would likely be a costly construction challenge; and
3. Potential in-filling of gravel from above (through deposition from airborne or waterborne sediment) or below (through settling of gravel or capillary movement of saline water through sediment-filled interstices) poses a risk to long term effectiveness, and could significantly inflate maintenance costs by requiring placement of more gravel.

Recommendations

Considering the lack of proven effectiveness on large areas, along with the apparent supply and transportation challenges and high estimated cost, consideration of gravel cover as a large area dust control measure is suitable for research and development. In the meantime, gravel cover may be useful for roads and small areas where other dust control measures are infeasible or undesirable. At this time, gravel cover is not a suitable basis for dust control resource allocation.

Chemical Treatment and Stabilization Products

Principle of Operations

Chemical treatment involves treating the soil surface with a chemical additive to increase inter-particle cohesion, thereby increasing the shear stress required to mobilize surface soil particles. A wide range of experimental and commercially available chemical soil treatments are available. Many are applied in water suspension or solution. These have been tested and shown effective to varying degrees, primarily on roads, parking lots, or locally disturbed areas.

Suitability

Several characteristics of the Salton Sea playa make widespread application of chemical treatments more challenging than in their typical applications. First, the unique surface chemistry of playa sediments may disrupt the function of some treatments or increase their degradation rate; therefore, any treatment would require site-specific effectiveness testing. Secondly, treatment of large areas (many square miles) is unusual and is likely to induce chemical production or availability challenges, while (depending on the nature of the material) potentially posing environmental challenges. Further, the long term reliability of surface treatments, many of which conventionally require regular re-application, is generally unknown, particularly in the conditions of the Salton Sea playa.

One common and relatively practicable version of this control approach is practiced at Owens Lake. Local brine is sprayed on dirt roads, forming a relatively hard, resistant surface. This practice is more effective and efficient than conventional road watering. Further, the local brine contains only solutes that occur naturally at the site, so that potential environmental impacts are minimized. Note that this special case of chemical treatment is practically identical to stabilization with brine (described previously).

Recommendations

While this approach has potential, particularly for small areas, dirt roads, or temporary application, the specific application of chemical surface treatments to saline playas has not been proven for extensive land areas. Therefore, this dust control measure, while appropriate for research and development, should not form the basis of resource allocation for large-scale dust control. Further research on implementation and performance is recommended, and small-scale or temporary use of chemical treatments may be included as part of an overall phased implementation strategy. Use of brine on roadways could be employed throughout facilities.

Tillage

Principle of Operations

Tillage as a dust control measure involves roughening the soil surface with a primary tillage implement, such as a large disk or plow. Tillage reduces emissions by increasing the soil surface roughness, reducing the wind velocity at the soil/air interface. It also exposes subsurface soil whose individual particles are bound together in somewhat cohesive units (or aggregates) that resist wind abrasion and increase micro-scale surface roughness. The roughened soil surface also traps mobile sand particles.

Suitability

Tillage is an effective farm management practice to reduce wind erosion on agricultural lands. However, the effectiveness of tillage for wind erosion control is short-lived, so that it must be repeated at regular intervals (seasonally or annually). Also, while the roughened soil surface emits less, the tillage operation itself is a source of considerable dust and exhaust emissions. This is recognized in Air Quality Management plans for agricultural areas that consider or restrict tillage methods, timing, and frequency.

Recommendations

Due to the limitations described above, tillage should not be considered further as a large-scale option for dust control on exposed portions of the Salton Sea playa. The high levels of emissions during tillage would in most cases make it unsuitable for most stabilization applications in the alternatives. This should be confirmed as part of the research and development effort.

Sand Fences

Principle of Operations

Sand fences reduce the wind velocity at the soil surface near the fence. In general, sand fences cause the heavier or coarser dust particles in the near-surface air stream to drop out of suspension adjacent to the fences. Deposited material is thereby prevented from further movement, reducing abrasion of the soil surface by mobile material. For large-area application, sand fences are generally arranged in parallel rows or herringbone arrays, oriented perpendicular to the prevailing wind direction during high wind events.

Suitability

Fences are commonly employed to reduce wind erosion from soils or to prevent the accumulation of wind-borne material in critical areas (for example, to prevent sand or snow accumulations on roadways). Sand fences are principally used to protect small areas or linear features, but some success has been recorded for temporarily controlling sand movement over large areas with regular arrays of sand fences. Because mobile sand or sand-sized particles are a major driving force for playa emissions, controlling or capturing mobile sand-sized particles can greatly reduce playa dust emissions rates. One issue with the long term performance of sand fences is that they can become filled with sand, and periodic removal of the trapped sand is required to allow continued functionality. One of the test fences at Owens Lake playa became buried within 4 months of installation (LADWP, 1992).

One important consideration for the suitability of sand fences is that an extensive network may be required to adequately control wind erosion over large areas. An investigation conducted for Owens playa estimated that more than 250 miles of fence were required to adequately control playa dust emissions on just 1 square mile with high levels of sand flux and supply (LADWP, 2000). The capital and O&M costs associated with sand fence construction over this large area are great. For permanent applications, the long term maintenance and replacement of fencing material can be a practical (as well as a financial) burden.

Recommendations

Due to the potentially dense networks and the ongoing maintenance required to remove accumulated sand and maintain effectiveness, sand fences do not appear suitable for long term or permanent implementation over large areas. However, this finding can be reviewed in site-specific field testing. As with chemical treatments, temporary use of sand fences could be included as part of an overall phased implementation strategy.

Results of Preliminary Prioritization of Options for Dust Control Measures

The preliminary prioritization of dust control options is summarized in Table H3-2. Priority was assigned based on performance criteria and feasibility issues described for each dust control measure. Highest priority dust control measures have been recommended and will be carried forward to form the basis for resource (capital and water) allocation in the alternatives. However, if other dust control measures prove more promising based on later findings, those dust control measures may be incorporated into detailed project-specific plans and designs prior to implementation.

Detailed Description of Suitable Options

This section reviews the options identified as potentially feasible in the preceding section with specific reference to the Salton Sea playa and describes potential implementation requirements.

Under the alternatives, the deployment of Air Quality Management would likely be phased, as constructible areas of the playa are exposed or dewatered. As these areas dewater, they would be characterized, and Air Quality Management plans would be refined for the constructible area. Several considerations of this process pertain to the suitable options discussed below. As areas dewater, the following would evolve over time, vary spatially across the playa, and gradually become known to those finalizing plans for playa stabilization:

- Emissions potential and need for dust control; and
- Suitability of playa for application of different dust control options

Suitability is defined narrowly in this section, so that only dust control measures meeting the performance criteria listed previously are discussed. However, these methods may not ultimately prove to be the preferred approach to Air Quality Management on Salton Sea playa. This is true for the following reasons:

1. A four-step air quality mitigation process is slated for implementation under the 2003 IID Water Conservation and Transfer Project MMRP (IID, 2003; SWRCB, 2002). Step 2 of this process includes research and development, including development of adaptive dust control measures for Salton Sea playa. The results and other new knowledge should be considered during final Air Quality Management planning and design.

2. Although proven, reliable methods have been identified for planning purposes, methods more appropriate to the Salton Sea playa may be developed over the 75-year study period, or more cost-effective or water efficient means of achieving desired control effectiveness may be devised. Uncertainty regarding the extent of control needed is even greater. Final maps of areas requiring control, and the required levels of effectiveness for that control, cannot be accurately predicted during the PEIR preparation.

3. The dust control measures identified as suitable here entail substantial capital, operations and maintenance, and water supply costs. Therefore, a broad range of technologies with similar or reduced requirements should be considered, and adopted if they meet other performance criteria (e.g., effective, reliable, feasible, and consistent with other features and objectives).

Planning for future consideration of a broad range of Air Quality Management actions would allow the future ecosystem restoration effort to make use of new knowledge, while establishing a viable Air Quality Management planning framework in the near term.

Of the possible Air Quality Management options discussed above, the following measures are considered suitable and consistent with the performance criteria:

1. Recommended temporary measures (for all emissive areas before permanent facilities are constructed) include control of traffic, sand fences, and surface treatment (chemical treatment and stabilization). All of these methods have been applied and proven for temporary dust control on small to large areas. Effectiveness under conditions at the Salton Sea is difficult to estimate. Options would be relatively restricted by the site conditions and response timeframe.

2. Recommended permanent measures (for Air Quality Management areas) include control of traffic, water efficient vegetation, and stabilization with brine. Stabilization with brine, while unproven at a large scale, is included for areas below the brine pond high water line, should this area prove to require control. Should it prove inadequate as described, operations could be altered to prolong wetting so that the measure would become seasonal surface wetting. Seasonal surface wetting is a proven measure, although it requires substantially more water. Control of traffic has been demonstrated to control emissions, but the level of effectiveness may prove inadequate in some areas. In these areas, where they occur above the brine pond high water level, the most water efficient of the proven dust control methods is water efficient vegetation.

Among the temporary measures, sand fences are more widely used for large-scale applications. Surface treatment (chemical treatment and stabilization) would require site-specific research on the playa, and could vary widely in methodology and cost, depending on the outcome of these investigations. At this point, sand fences are described in detail as the recommended temporary Air Quality Management for planning purposes.

Control of traffic and restriction of access are discussed only briefly, because these measures are slated for more intensive development under Step 1 of the four-step air quality mitigation plan in the 2003 IID Water Conservation and Transfer Project MMRP. This measure may ultimately prove to be the most cost-effective approach to controlling emissions from Salton Sea playa, although implementation and enforcement may be problematic.

Water efficient vegetation is described as the permanent dust control measure for emissive playa not developed for other land uses (Air Quality Management areas), unless a playa area is not suited to vegetation. Literature and experience supporting water efficient vegetation are extensive. In this memorandum, this dust control measure is described in the greatest detail practicable to facilitate development and analysis of the alternatives. Details could be altered based on site-specific investigations. Site-specific investigations may also lead to implementation of different dust control measures. In general, capital and water planned for use in water efficient vegetation would need to be adequate for any replacement measure.

One example of areas not suited to vegetation is the playa periodically used for brine storage, because vegetation planted in these areas would likely be killed when flooded with brine. Stabilization with brine is less proven and developed, but conceptually relatively simple. Infrastructure is described here based on preliminary assumptions regarding brine application requirements and a conceptual design. Field pilot testing of this measure is anticipated as part of playa dust control research and development. Discussion of this dust control measure in this memorandum is rather brief, pending development of additional information as part of that effort.

Temporary Dust Control Measures

Dust control measures applied on Exposed Playa before construction of permanent facilities are termed temporary. These areas might be planned for any ultimate land use, but until the permanent facilities are completed, they may require some form of dust control. Dust control may not be needed where evidence indicates that an area is not emissive and where this finding is sustained through ongoing observations.

Temporary dust control measures that meet the listed performance criteria include the following:

- Restricted access;
- Sand fences; and
- Surface treatment.

Control of access, which may be applied on either a temporary or permanent basis, is discussed under Permanent dust control measures. Sand fences and surface treatment are discussed in the following sections.

Sand Fences

Sand fences limit emissions by capturing mobile sand that would otherwise abrade the soil surface and produce dust emissions. Tests of sand fences on Owens Lake playa suggest that appropriately implemented sand fences can limit playa dust emissions (WESTEC, 1984; AeroVironment, 1992; and Air Quality Group, 1995).

Sand fences are a viable because they:

1. Are well-proven for dust control and easily designed;
2. Are quickly and easily constructed;
3. Can be placed on playa independent of other supporting infrastructure;
4. Can be placed on nearly all terrain and natural substrate conditions; and
5. Require little short-term operation effort.

Where evolving playa exposure or other local conditions warrant, sand fences may be a viable alternative for temporary control, until a more permanent can be implemented. One possible application at Salton Sea is in poorly drained beach areas where permanent facilities cannot yet be constructed, but where there is a need for immediate control to meet air quality goals. Also, where mobile sand is clearly present and problematic (e.g., adjacent to dune or beach deposits), sand fences may prove particularly helpful in suppressing erosive mobile sand.

Sand Fence Concept Description

Sand fences are usually constructed of a tough polyethylene material that is cut into a rectangular mesh with about 50 percent porosity, and attached to a line of fence posts. The posts are usually 2 to 6 feet in height, attached to stakes anchored in the ground.

An array of fences is required to cover large areas, such as on an emissive playa. The playa surface itself can be a source of the mobile sand particles. Factors affecting fence design include proximity to other facilities, expected sand loading, wind direction and speed, and control efficiency required. Fence height, spacing, orientation, placement, and fabric porosity are key design parameters that are matched to local conditions. Computer modeling may be useful to optimize the selection of design parameter values.

Sand Fence Cost Estimates

Sand fence cost depends on the length and spacing of fence. As discussed previously, sand fence spacing varies depending on sand loading, wind direction and speed, and control efficiency. Analyses for possible sand fence implementation at Owens Lake playa suggest spacing might vary from about 10 feet to over 100 feet according to target control efficiency and selected fence height (LADWP, 2000). Because sand fence installation would be independent of most other supporting infrastructure, the density of sand fence spacing could be increased by installing additional fences in the intervals between previously installed fences, if monitoring showed a more dense spacing is needed to meet control requirements.

Assuming an initial spacing of 30 feet, 1 acre would require 1,452 feet of fence. The level of sand fence maintenance required would depend on the volume of material removed, frequency of cleaning, and distance to areas where material can be re-deposited. Sand collected in fences could be reused for drainage envelope material (see later discussion of water efficient vegetation), or be stabilized on the surface by other means. Given the initially low bearing capacity of the non-constructible areas, it may prove most practical to continue to add fences where existing fence volume fills, and to grade or remove collected material during construction of subsequent permanent land management infrastructure, as appropriate for the designated permanent land use of an area.

Surface Treatment

Surface treatments limit emissions by strengthening the surface of the soil, or by protecting the soil surface through protection with a non-emissive layer.

Surface treatments are usually applied in liquid solution or suspension, requiring coverage of the potentially emissive area by water truck or air tanker. Materials range from inorganic salts, to organic substances, to fibrous materials. Few of the materials have been tested extensively in a playa environment. Each would have to be considered from an environmental viewpoint to avoid potential impacts on the playa ecosystem.

This is included among suitable, temporary options because applied materials are typically not permanent, but offer an alternative to sand fences, requiring even less infrastructure. Surface treatments are well suited for “spot” treatment, but may require heavy vehicles (such as water trucks or spray rigs) for application. Aerial applications (as used in wildfire restoration across both California and Nevada) are becoming more routine management practices and can cover hundreds of square miles of land rapidly.

In combination with other treatments, like vegetation and even surface wetting, chemical treatments can be a highly effective . Current Desert Research Institute (DRI) projects have found the application of tackifiers and surfactants to provide good stabilization over seasonal time frames. Furthermore, development of playa-specific treatments (e.g., a divalent cation surfactant) could increase water penetration by reducing soil dispersion before application of surface brine. The chemical breakdown or longevity of treatment would need to be tested and understood before application.

Permanent Dust Control Measures

Unless demonstrated to be stable by monitoring or some other means, areas not designated for other land uses may require permanent Air Quality Management. As discussed previously, future monitoring, research, and development may indicate that some areas can be maintained in a stable condition without permanent control measures. Research may also result in effective and cost- and water efficient options for stabilizing playa surfaces. When permanent controls are designed for constructible areas designated for Air Quality Management, the best available information on permanent Air Quality Management will be considered. Based on performance criteria discussed previously, suitable options recommended for planning purposes include the following:

- Restricted access;
- Water efficient vegetation; and
- Stabilization with brine.

These measures are discussed in the following sections.

Restricted Access

Access restrictions to traffic control are a critical element of Air Quality Management, regardless of the implemented. Disturbance of native crusts by traffic works directly against playa stability. Not only is there the direct benefit of reduced traffic-induced emissions, but other dust control measures are complemented by maintenance of a stable soil surface (e.g., soil crust, or salt-cemented soil crust), wherever and whenever such crusts exist.

Design criteria for an acceptable and effective traffic control plan are as follows:

- Limit public access, especially off-highway vehicle (OHV) access, to the extent legally and practicably feasible, to minimize disturbance of natural crusts and soils surfaces in future exposed shoreline areas;

- Plan for and accommodate necessary and legitimate traffic, while minimizing its impact on playa emissions rates; and

- Implement effective and realistic infrastructure and enforcement.

Characteristics of an effective planning and implementation process might include the following:

- Participatory planning of traffic control approach and plan, including key stakeholders (landowners, residents, recreational users, OHV organizations, agency representatives, traffic officials, and agency wildlife and land managers);

- Clear traffic guidelines and requirements;

- Ongoing public education; and

- Sufficient and effective policing and enforcement, especially at the beginning of implementation.

Associated infrastructure elements include roads and paths that meet recreational and infrastructure needs, and effective barriers and fencing, where necessary. Ongoing public involvement and education would also be critical to successful maintenance of the traffic control plan.

Water Efficient Vegetation

Vegetative dust control limits emissions by altering wind velocities at the soil surface. Wind speeds within and beneath a plant canopy are reduced because of the resistance of that canopy to the flow of air. Water efficient vegetation is being developed in greater detail here as the most water- and capital-efficient that meets the performance criteria established for the PEIR. While other more efficient approaches may be proven and employed at a future date, measures currently known to meet performance criteria serve as the basis for allocation of resources for Air Quality Management.

Plant species adapted to the playa environment must tolerate salinity and grow and survive with as little irrigation water as possible. In many parts of the arid Salton Sea playa environment, vegetation densities required to control dust may be difficult to establish and sustain without irrigation. Shallow groundwater may be present, but it is generally too saline to be a resource to plants. Establishing and maintaining adequate vegetation density with native rainfall or available groundwater is preferable to construction of irrigation infrastructure.

Native plants should be considered because they have generally evolved in dry, alkaline conditions. Certain non-native vegetation may be attractive where species combine similar environmental tolerances with propagation, irrigation, or habitat advantages. Agronomic considerations, such as nutrient requirements or ongoing management needs, may also be significant in species selection.

Potential difficulties associated with large-scale planting of native plants include limited availability of propagation material and poorly documented agronomic characteristics. However, with a few years' lead time before implementation, these issues may be addressed through targeted effort. The use of saltgrass at Owens Lake playa provides numerous lessons in this regard.

Attachment 2 of Appendix H-3 summarizes relevant information related to vegetation of Exposed Playa with saltgrass and shrubs, irrigation and drainage of playa surfaces, playa soil and water quality considerations, and requirements to achieve adequate dust control.

Summary of Water Efficient Vegetation

Water efficient vegetation appears to have significant promise for controlling dust emissions from the Salton Sea playa, based on anticipated conditions on the playa and performance of this at similar sites. Following are positive attributes supporting a preliminary finding of suitability:

- Fairly limited water demand relative to other water-requiring stabilization methods. Projected new (inflow) water requirements are about 1 foot per year;
- Tolerance for a wide range of water quality, possibly including water with relatively high selenium concentration;
- Siltation of conveyance and irrigation facilities mitigated by the proposed inflow de-silting facility, and (for drip irrigation) by filtration;
- Potential for reliable dust control after establishment of vegetation; and
- Ecological similarity to native desert plant communities.

Challenges include the following:

- Identification, construction, and operation of constructible areas on a schedule that encourages proactive control of emissions before they occur. This may require that temporary measures (see previous discussion) be applied during an interim period;

- Potential need for subsurface drainage (e.g., open channel or buried tile drains) on some or all of the controlled area, and for disposal or reuse of drainage flows;
- Likely requirement for supplemental irrigation;
- Propagation, planting, and establishment of native vegetation require several years of lead time; and
- Substantial capital, operations, and maintenance costs.

Should they be included, facilities associated with drip irrigation (for blending, filtration, control of scaling and biological plugging, fertigation) would be both costly and high maintenance, relative to simpler irrigation technology.

Costs associated with vegetation are highly sensitive to the complexity of required infrastructure. Irrigators surrounding the Salton Sea have extensive knowledge on irrigation and drainage of similar lands. This knowledge will likely lead to investigating and proving the most cost and water efficient approaches adapted to the range of future playa conditions. The details of this future engineering knowledge of playa plant communities, irrigation, and drainage cannot reasonably be anticipated at this time. However, at least some of the Salton Sea playa would likely share the physical challenges of much of the Owens Lake playa, which include fine-textured, poorly drained, saline-sodic soils and extremely saline shallow groundwater. Therefore, irrigation and drainage systems that have worked well for the establishment and maintenance of plant cover on the Owens Lake playa have been adapted for planning (water and capital allocation) purposes for the alternatives in the PEIR.

It is anticipated that this and other technologies will be objectively evaluated in pilot testing of water efficient vegetation, and that the most appropriate technology will eventually be applied wherever water efficient vegetation is constructed. The constructed facilities may therefore differ from what is described here, but should achieve generally the same purposes of reliably and sustainably supporting protective plant growth on the playa.

Design Criteria

This section summarizes design criteria for water efficient vegetation. These criteria are preliminary and intended for planning purposes. Further refinements during development and pilot testing at the Salton Sea playa would result in refined criteria to guide ongoing design efforts.

Criteria presented in these sections pertain to the following:

- Plants and growth requirements;
- Soil conditions;
- Water requirements (quality and quantity);
- Flood flow passage or reuse; and
- Irrigation and drainage infrastructure.

Plants and Growth Requirements

Attachment 3 of Appendix H-3 contains an evaluation of the suitability of plant species for planting as water efficient vegetation. Species' tolerance of high salinity and poor drainage were the principal criteria applied to evaluate suitability and rank species. On the irrigated Salton Sea playa, soil conditions would be improved in the zone wetted and leached by irrigation. However, this improvement may be limited in quality and extent by local conditions of low permeability, elevated and saline shallow groundwater, or the influence of topography on surface drainage and depth to shallow groundwater. Also, unlike springwater that may support wetland desert vegetation, shallow groundwater on the playa would generally be too saline to support even the most tolerant species. Therefore, the selection of species with excellent salt and drainage tolerance would be prudent.

The highest ranking species are shrubs. A number of these species have been grown successfully on the Owens Lake playa, and all could provide a protective plant canopy for dust control. The highest ranking species have been the subject of extensive ecophysiological research at Owens Lake playa. Therefore, plant water and nutritional requirements are relatively well understood.

Planting would need to meet the following criteria:

- Soils would need to be initially leached by irrigation before planting could occur. The manner and amount of leaching depend on site-specific conditions (natural drainage, soil permeability, soil texture) and on irrigation and drainage methods used. With drip irrigation, for example, initial leaching is conducted to reduce salinity in a relatively small proportion of the surface soil volume, where the young seeds or plants are to be placed. This greatly reduces the amount of water that must be applied, or drainage that must be removed. At Owens Lake, where playa soils were, in some cases, mostly salt, initial leaching was accomplished in about 40 days by application of several inches of water. Other approaches to leaching (e.g., empoldering or surface irrigation) are possible, but often require much more water. During certain restoration phases, additional water for leaching may be available. For any irrigation system, long term leaching is incorporated into the long term leaching fraction of applied water;

- Plants or seeds can be planted. Planting from seed requires more time for plant development and may be difficult where soil conditions are as challenging as they are on a saline playa. In either case, an adequate supply of planting material must be purchased or developed;

- Plants should be spaced to provide adequate ground cover. Based on literature and Owens Lake playa results, about 20 percent cover of exposed surface area should be adequate. This level of cover could be achieved with *Atriplex parryi* planted in rows spaced at 10 feet, with individual plants spaced an average of 3 feet apart along each row. Assumptions for this plant spacing are shown in Table H3-3; and

- The plant community could consist of one or more species, if the pattern and density of cover are effective at controlling dust emissions. Ecosystem benefits can be taken into account in design of the plant community, but would be a secondary consideration after dust control effectiveness, reliability, and cost of establishment and operation.

Table H3-3
Planting Plan Parameters

Parameter	Value
Canopy density	70%
Individual plant diameter	3.5 feet
Individual plant average radius	1.75 feet
Row spacing	10 feet
Plant spacing in row	3 feet
Plant population	1,452 plants/acre
Shrub cover (total canopy)	32%
Ground cover (area vertically covered by plant material)	22%
Max in-row radius (half of in-row spacing)	1.5 feet
Width across row (assuming elliptical shrub extension across rows)	2.0 feet
Alley width (between shrub canopies)	5.9 feet

Table H3-3
Planting Plan Parameters

Parameter	Value
Shrub cover (cross-row transect intersection with canopy)	41%
Population (% of Owens saltgrass planting)	11%

Planting should be scheduled after an initial period of irrigation for soil salinity reduction (reclamation) and a suitable dry-down period. Planting should also be scheduled during early spring to allow for maximum establishment and growth before the next winter season.

Soil Conditions

Soil conditions would need to be created and maintained in the following ranges:

- **Moisture and drainage:** Available moisture in the drained root zone must supply the depth of water required by the plant during each period of growth. These amounts are discussed below and summarized in Attachment 3 of Appendix H-3. The depth of the drained root zone should be planned for a minimum of 2 feet, with 3 feet or more preferred;
- **Salinity:** Average root zone salinity target should be an electrical conductivity (EC) of 30 deciSiemens/meter (dS/m) or less. (An EC of 10 dS is about equal to 8,000 mg/L TDS in this salinity range.) Where necessary to control site drainage problems after establishment, levels up to 60 dS/m may be tolerated with monitoring of plants. Initial reclamation to create these conditions should be feasible in less than 2 months with adequate drainage, but is best planned for an entire season. Initial root zone salinity for optimum establishment should be in the range of 20 dS/m. Minimum salinity levels are defined by the soil in equilibrium with applied water (see applied water under Water Requirements, below). When irrigated with water having a low salinity, fine textured, saline-sodic soils can disperse, hindering further irrigation and plant growth;
- **Fertility:** Native shrubs' salt tolerance, water use efficiency, and growth rates may be significantly enhanced when appropriate nutrients are present or provided. Rates of nitrogen, phosphorus, and other nutrient additions are typically low compared to the requirements of most commonly cultivated agricultural crops. Indications for several species have been developed for Owens Lake (Richards, 2002, 2003, 2004, and 2005);
- **Specific elements:** Non-nutrient specific element concentrations should be maintained in ranges that are not phytotoxic and do not otherwise interfere with plant growth. Sensitivity of the soil to elevated sodium can be avoided by maintaining design-applied water salinity levels; and
- **Physical properties:** During construction, overcompaction from equipment traffic on soil with high moisture content should be avoided. Depending on the manner of planting, initial soil preparation may include several tillage steps designed to create a favorable planting and establishment environment. Thereafter, no tillage and little traffic should be needed in planted blocks. During the irrigation season, traffic in the blocks should be avoided because of the risk of compaction. As mentioned above, soil dispersion and resulting degradation in physical properties should be avoided by maintaining designed irrigation water salinity levels.

Water Requirements (Quality and Quantity)

Water balance quantities would be based on the following assumptions:

- **Limited Reclamation:** Limited reclamation entails irrigation of saline lands to wash salinity through the surface soil layers and enable plant growth. Water requirements and drainage volumes for this purpose vary widely, depending on the irrigation system. For subsurface, requirements are reasonably small, a few inches of water applied over 1 to 2 months; and

- **Long term Applied water:** 1.0 to 1.3 (average of 1.2) feet per year. Monthly distribution of water balance quantities assumed irrigation rates are for the period after initial reclamation (when more water may be applied), and before long term application rates are determined. Long term application rates would be adjusted based on site-specific observations during the first 2 years of operation, and maintained generally at the site-specific levels thereafter. Site-specific irrigation rates are set at levels that balance drainage and application rates, based on observed field hydrology, while providing enough moisture to maintain plant growth over the long term.

- **Drainage volume:** Of applied water, about 0.1 to 0.2 (average 0.13) foot per year would flow to drains. Drainage return flow volumes would also be affected by the depth of shallow groundwater relative to drain depth, the rate of subsurface flow to drains, and the volume of surface water contributions.

Water quality requirements are included among calculations shown on the summary worksheet in Attachment 3 of Appendix H-3. These assumptions would be as follows:

- **General salinity target:** To avoid soil dispersion of fine and textured sodic soils, water would be applied at about 10 dS/m;

- **Blending:** Drainage return flows or other saline water (e.g., from the Brine Sink) would be blended with inflow as necessary to meet the water supply salinity criterion. Assuming blending of inflow at about 3.3 dS/m with Brine Sink water, the blend would average about 13 percent Brine Sink water over the long term. Of the 1.2 feet applied, about 1 foot would be from inflow;

- **Suspended solids:** Standards for filtration would depend on irrigation method. For subsurface drip irrigation, substantial filtration would be required. Final filtration should be downstream of water supply changes (e.g., blending, temperature change) causing precipitation, and primary and secondary filtration may increase system reliability. Gross screening of water supply upstream of filters may be warranted if foreign material is present in significant amounts. If scaling potential is significant because of blending or other factors, water treatment would have to be considered (see water treatment, below);

- **Water treatment:** Water may require treatment with acid or anti-scalant to prevent or mitigate scaling. Chlorine or bromine treatment may be required periodically to prevent biological plugging. Small concentrations of herbicide may be needed to prevent root intrusion into drippers. These practices are standard for subsurface drip irrigation applications;

- **Fertility:** Fertilizer would need to be added, at least during establishment of water efficient vegetation, and perhaps at lower levels over the long term. Fertilizer that would exacerbate scaling problems should not be applied with irrigation water; and

- **Specific elements:** At high applied water salinity, it would probably not be necessary to manage the concentration of specific elements in the applied water to meet plant requirements. Concentrations need only be maintained within the range of plant growth tolerance, which in many cases is much higher than other ecological risk thresholds, and, therefore, the concentration controls would be driven more by ecological risk constraints than by plant growth requirements. This assumes that operation of subsurface drip irrigation is controlled such that areas with prolonged or frequent surface flooding are strictly minimized for both plant growth and ecological risk reasons.[3]

Flood Flow Passage or Reuse

Depending on the siting of an Air Quality Management area and the design of other infrastructure components, there would be potential for flood flows to affect infrastructure and planted vegetation. The following would be required for handling of flood flows:

- Dispersed flow across the facilities and associated temporary (several days) standing water are acceptable. Once plants are established, they are more resistant to the mechanical and root-zone effects of these flood flows. Plants are more sensitive to flooding during warmer periods and periods of active growth. On the Salton Sea playa, this would only exclude a portion of the winter period, so that prolonged flooding should be avoided as practicable;
- Evacuation of flood flows can be facilitated by grading outlets to closed depressions and by augmenting surface and subsurface drainage (including French drains in poorly drained depressions) in areas that prove particularly difficult to drain;
- Concentrated, high-velocity flows should be avoided because they remove soil, plants, and infrastructure from areas and redeposit them downstream;
- Placement of facilities below ground may help to avoid the impact of flood flows. Where infrastructure is aboveground, it should be raised, water resistant, or reinforced to withstand or escape flood flows; and
- Dispersed flood flows can benefit water efficient vegetation by leaching salts downward and recharging soil moisture, which may reduce subsequent irrigation rates.

Irrigation and Drainage Infrastructure

Irrigation infrastructure, as noted previously for the planning model of water efficient vegetation, infrastructure would need to satisfy the following criteria:

- Buried drip tubing at 10-foot spacing. Burial depth would depend on selected species and planting method, but is likely about 9 inches for *Atriplex parryi* transplants. Tube spacing could be altered based on site-specific information. If upstream infrastructure is sized to allow higher flow rates, additional drip tubing and associated planting could be added to change the spacing to 5 feet. It is expected that this would only need to be considered in the most intensely emissive areas;
- Capable of delivering design applied water rates on design schedule. Also flexible to allow delivery of heavier reclamation rates, and potentially somewhat reduced long term rates;
- Emitters adapted to heavy soils with slow intake rates, that is, many emitters with low flow rates; and

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[3] For example, selenium is not phytotoxic to water efficient vegetation in the ranges observed in the inflows from the drainage and tail water from IID, and would not pose ecological risk if maintained subsurface. Selenium uptake can be considerable for *Atriplex* spp. (Whiston, 1987; Vickerman et al., 2002). When sulfate concentrations are also high (as they would be in the blended water), selenium uptake is depressed, potentially reducing the risk of selenium introduction into the food chain through this pathway. However, at high concentrations of irrigation water selenium (7 to 14 micrograms [µg]/L), uptake of selenium might be considerable. Therefore, focused work on selenium uptake by *Atriplex* and other adapted shrubs, under conditions anticipated on the playa, will be required. Once uptake and tissue concentrations have been predicted with greater confidence, appropriate ecological risk analyses will be needed.

- System resistant to plugging from biological growth, root intrusion, precipitation, and soil.

Drainage infrastructure, as noted previously, should satisfy the following criteria:

- Perforated subsurface pipe with flow collected to sumps and removed for disposal by gravity if possible, or pumped if necessary;
- Capable of removing design or greater drainage flow rates, based on site-specific soils and shallow groundwater information. Capable of maintaining the design depth of drained root zone throughout the site under normal irrigated conditions; and
- Flexible plan to allow for retrofit of underperforming areas with French drains and, where necessary, new drainage laterals.

Water Efficient Vegetation Concept Description

A complete water efficient vegetation system for a constructible area of water efficient would include some or all of the following components:

- Pressurized major conveyance supply line, although it is possible that constructible areas or portions of constructible areas could use open-ditch supply conveyance and have independent pump systems;
- Turnout facilities and primary distribution laterals for filtering, distributing, and controlling flow to discrete portions of the area;
- Field piping system, including field irrigation components;
- Subsurface drainage collection and pumping (if required); and
- Utilities and supporting civil infrastructure.

The basic concept of an irrigation layout for a water efficient vegetation is shown in Figure H3-4. The figure shows a hypothetical situation where the Exposed Playa immediately adjacent to the shoreline of the receding sea, the most recently exposed section of the playa, is too soft to support construction of permanent infrastructure. The gridded layout of a “constructible area” of an irrigation system is shown on the portion of the playa that can support infrastructure construction. The grid-type layout of the system allows subdivision of the entire area into square irrigation fields of a manageable size. The exact size of the fields is somewhat flexible according to the situation, but field sizes of about 10 to 100 acres are most likely. Water is delivered from a main supply pipeline to the fields through supply laterals. Supply lateral turnouts are spaced at intervals along the main supply line to match the chosen field grid size.

A detailed concept of a typical field is shown in Figure H3-5. At each field, water from the supply laterals enters the field through a field submain, which distributes the water to drip tubes spaced at regular intervals across the field. Drip tubes are 0.5 to 1-inch-diameter polyethylene tubes with drip emitters spaced at regular intervals along the length of the tube. Tube spacing across the field, emitter spacing along the tube, tube size, and emitter size are optimized based on the plant spacing and water demand of the chosen vegetation. Flush laterals at the downstream end of the drip tubes allow occasional flushing of accumulated debris from the small-diameter drip tubes.

Support facilities required for drip irrigation include filtration of supply water, facilities for delivery of fertilizer and other additives (fertigation) to the irrigation waters, and power and control facilities. For the concept layout shown in Figure H3-5, these facilities would most conveniently be located at the supply lateral turnout to serve the fields along that supply lateral. An example turnout facility layout is shown in Figure H3-6. The number and size of the filters at the turnout would be determined by such factors as the size and number of fields served within the turnout, the expected quality of the supply water, and the rate of water delivery to the fields. The filter banks and fertigation facilities can be made expandable to allow phased addition of fields to the supply lateral, as new areas requiring dust control are exposed. A close-up of a typical sand media type filtration system for drip irrigation is shown in Figure H3-7.

If local blending of saline and fresh water is required, blending facilities would be located at the turnouts, upstream from the filters. However, centralized blending would be possible for many Air Quality Management locations.

As discussed above, subsurface drainage may be required to provide an adequately drained root zone for plant development. If required, the general layout of the drain system would mimic that shown in Figure H3-8. Buried drain line laterals, usually 6 to 8 inches perforated polyethylene with a sand backfill, are spaced at intervals beneath the irrigated area. The spacing is determined by local soil conditions and anticipated water volume loading. In areas with less permeable soil conditions or higher water loading, more densely spaced drain lines would be required. The field drain lines connect to collector drains, which convey the collected drain lines by gravity to a central sump, from which the water is pumped or discharged according to the local needs.

In some circumstances, open ditches, as opposed to buried perforated drains, may be suitable for providing needed drainage. However, the capital cost savings that may be realized with installation of open drains is likely to be offset by performance and maintenance issues, as well as associated ecological risk and environmental monitoring.

Water Efficient Vegetation Cost Considerations

The cost for implementing an irrigated vegetation on the Salton Sea playa would vary with site-specific considerations, such as plant density and water demand, site conditions related to trafficability and constructibility, and the extent of required major conveyance pipelines or canals. However, as discussed above, the major components of the system are generally the same, irrespective of these site-specific conditions. Potentially significant cost considerations are whether water blending and subsurface drainage are required, and how widely alternative irrigation and drainage (for example, surface irrigation, open drains) can be applied.

As discussed above, over 3 square miles of irrigated vegetation dust control measure were constructed and are now operational on Owens Lake playa. The vegetation dust control measure at Owens required both fresh/saline water blending and subsurface drainage.

Site-specific considerations for implementing a similar system at Salton Sea might provide some cost savings as compared to the Owens Lake playa system. For instance, planting densities at Owens Lake were about 10 times what has been recommended for shrubs at Salton Sea playa, and twice as much drip tubing and plant cover were required. These factors would significantly reduce the cost of water efficient vegetation relative to the cost of the Owens Lake playa facilities.

Stabilization with Brine

There are certain areas of the playa where water efficient vegetation is not practical, particularly where conditions are unsuited to growing plants. Large areas of playa are intermittently inundated by brine as the brine pond elevation rises and falls. If these areas prove emissive, effective permanent dust control will need to be accomplished by some other means, such as stabilization with brine.

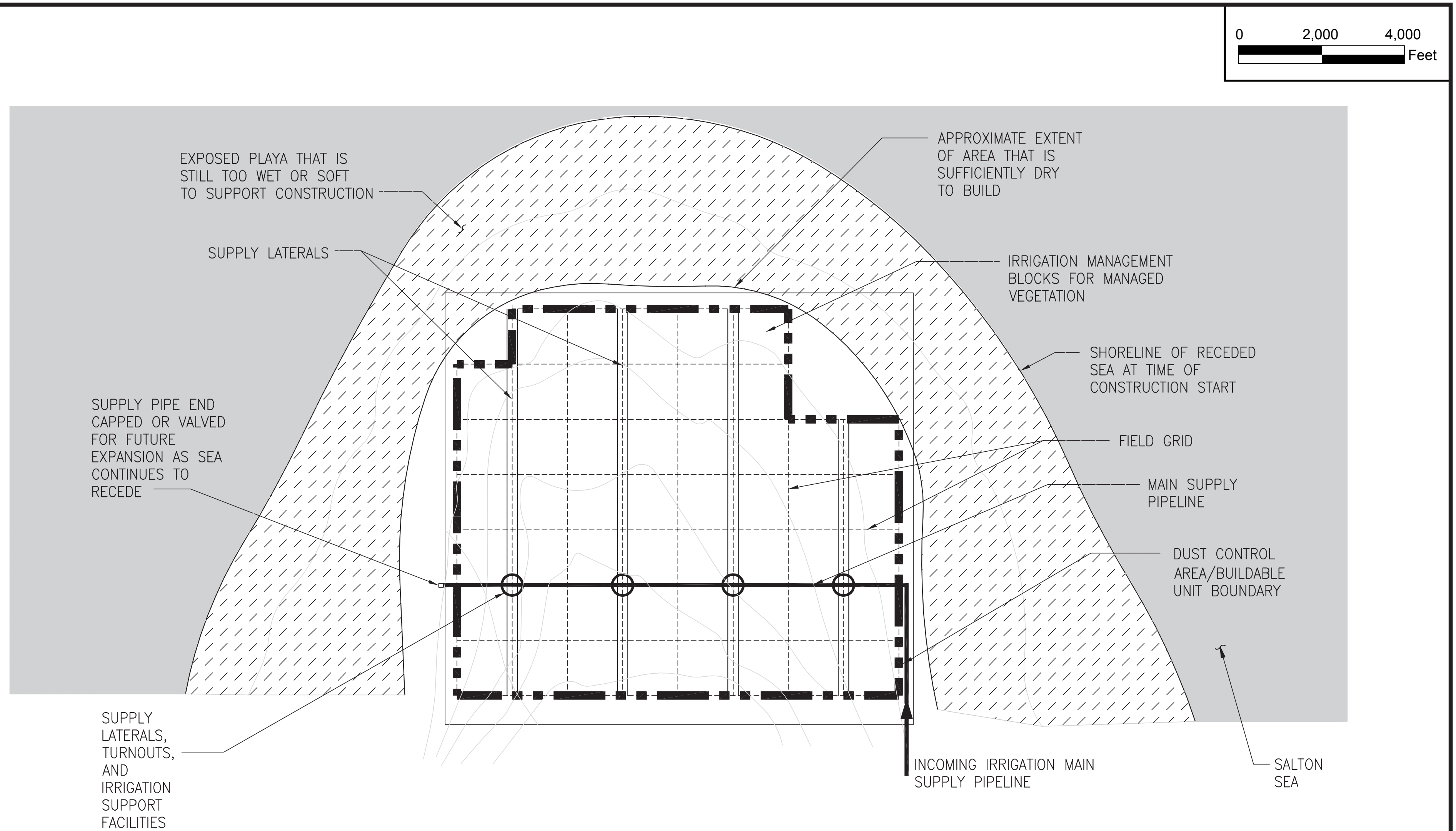

FIGURE H3-4
IRRIGATED VEGETATION DUST CONTROL MEASURE — TYPICAL CONSTRUCTIBLE LAYOUT

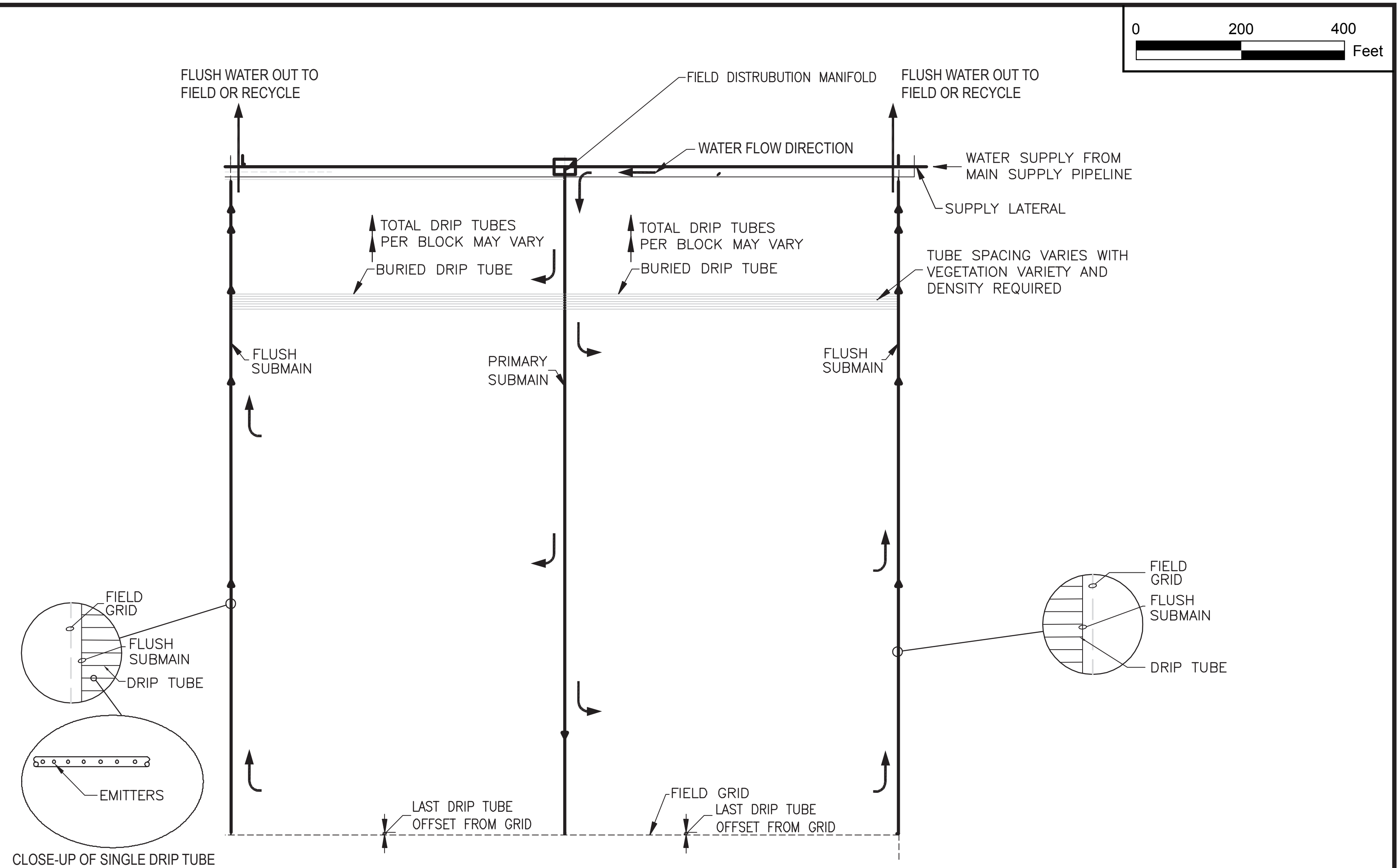

FIGURE H3-5
TYPICAL IRRIGATION BLOCK IN AN IRRIGATION DUST CONTROL MEASURE (DRIP IRRIGATION)

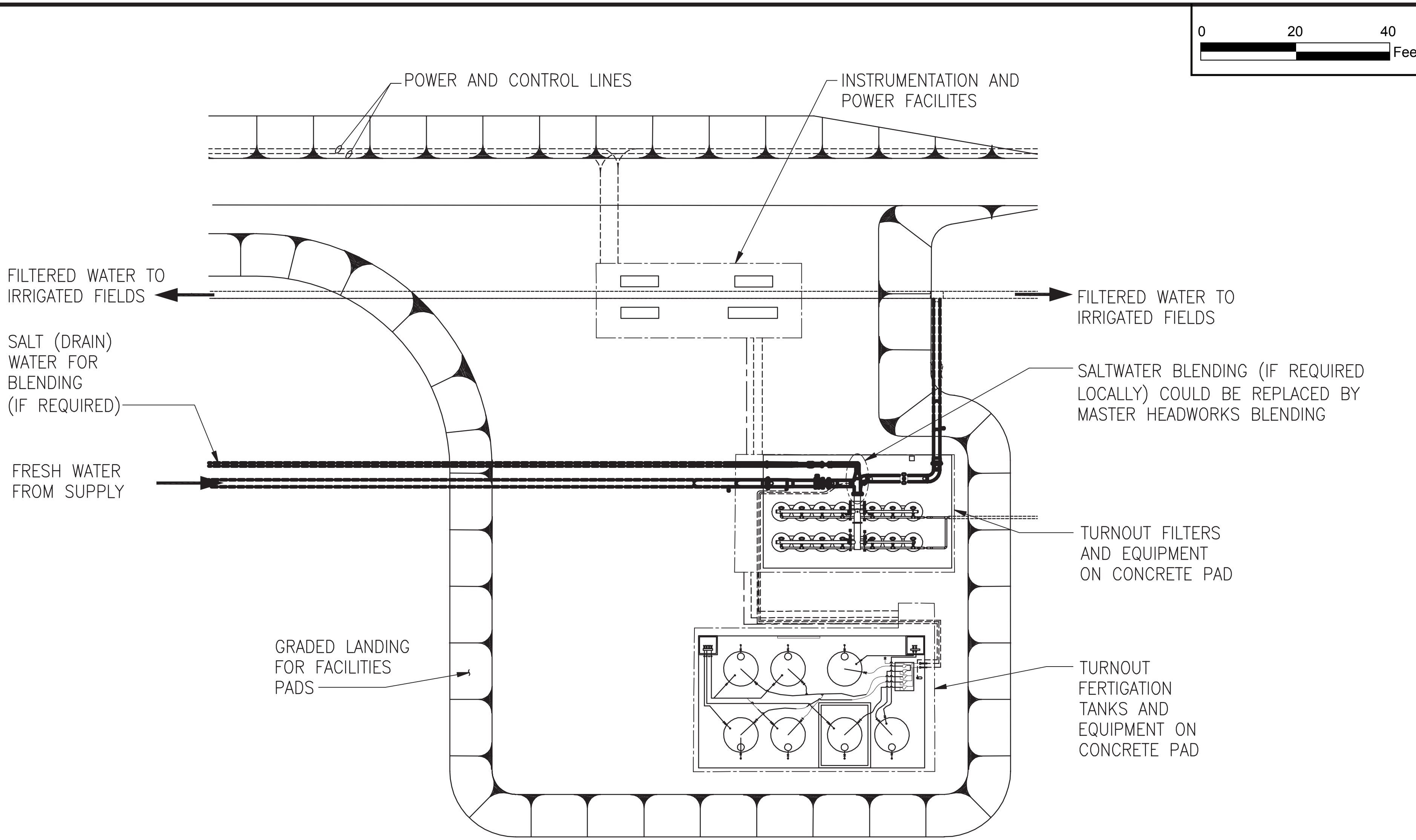

FIGURE H3-6
EXAMPLE TURNOUT FACILITY PLAN FOR BLENDED WATER IRRIGATION SYSTEM

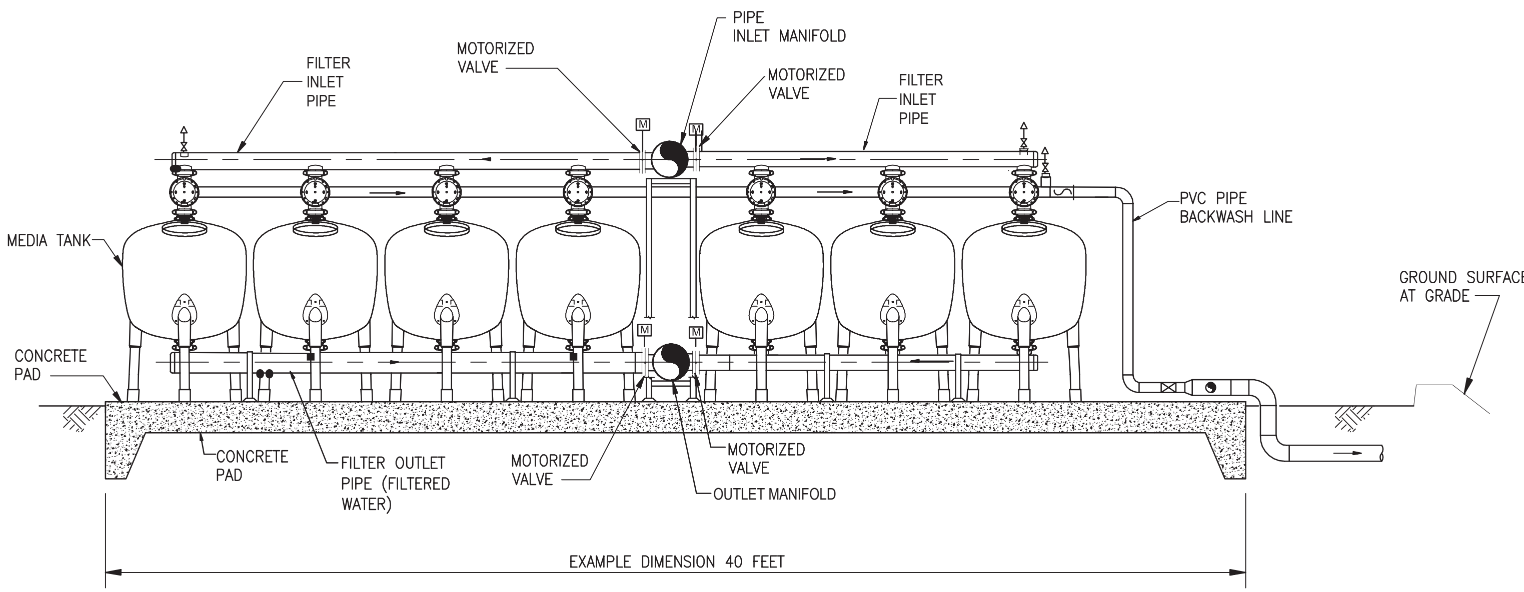

FIGURE H3-7
TYPICAL CROSS SECTION FOR SAND MEDIA FILTRATION STATION FOR DRIP IRRIGATION

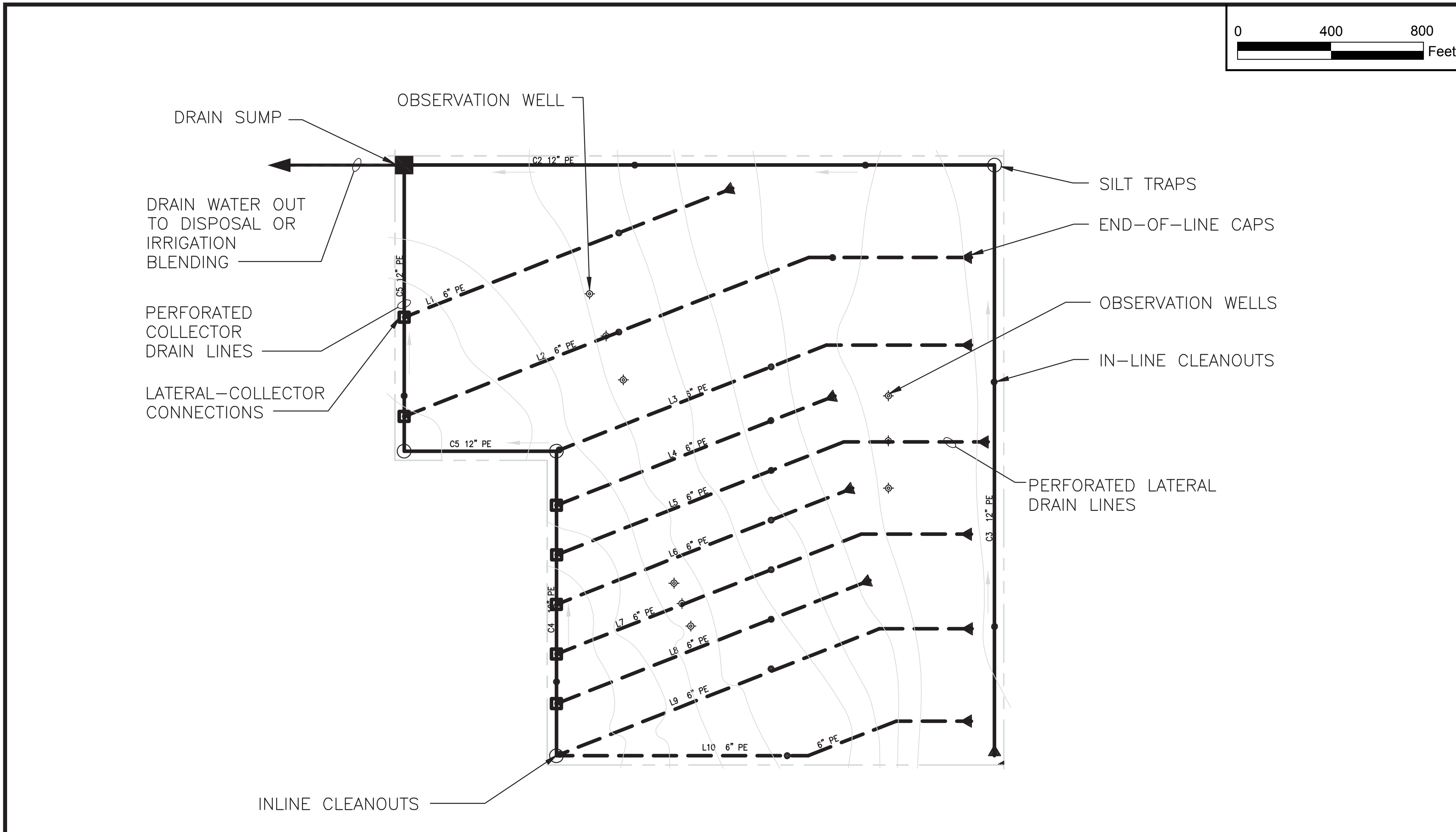

FIGURE H3-8
TYPICAL DRAINAGE LAYOUT FOR AN IRRIGATED VEGETATION DUST CONTROL MEASURES

This dust control measure involves periodic restoration of a generally stable crust by stabilization with brine. It is being developed in greater detail here as the most water- and capital-efficient dust control measure available, even in concept, to address areas below the brine pond high water level. This measure does not meet performance criteria established for the alternatives. This or other more efficient approaches may ultimately be proven and employed as necessary in areas below the brine pond water line. For now, for areas below the brine pond high water line, stabilization with brine is used as a basis for allocation of resources for Air Quality Management.

Previous work suggests that, for playas containing evaporate salt minerals, crust conditions and playa stability can depend on meteorological conditions (DWR, 2005a). Suspected meteorological triggers (prolonged low temperature, high relative humidity) for softening of the Owens playa have been identified. Comparison of weather records for the Salton Sea area and Owens Lake suggests that these trigger conditions occur much less frequently at Salton Sea, with about 1 percent as frequently at Salton Sea as at Owens Lake. Although certain sulfate minerals key to salt crust formation and softening processes at Owens Lake may also occur at the Salton Sea, the different meteorological conditions would support stable crust for much longer periods at Salton Sea. Therefore, although stable crust may not provide perennial protection from dust emissions under natural conditions, research and monitoring may show that natural periodic repair of the salt crust may keep emissions rates from Salton Sea playa low. In addition, enhancement of the natural salt crust through management activities may increase the reliability of a sufficiently stable crust to control emissions.

The mineralogy and dynamics of Salton Sea playa crusts are under investigation. However, it is possible that in the absence of disturbance by traffic, these crusts might remain stable over extended periods. Enhancing the salt crust through stabilization with brine may extend the period over which the crusts remain stable.

In many of the alternatives where this dust control measure might be applied, the area flooded with salt water will fluctuate and generally decline over many decades. The most probable time and site of application is in the area around the long term brine pond that is periodically exposed. The probable water supply would be the brine, which at this stage would be quite saline (> 100,000 mg/L TDS). The high salinity of applied water would thus minimize food-chain development and ecological risk associated with implementation of this dust control measure.

Possible layouts and design criteria for stabilization with brine are presented in the following sections.

Design Criteria

This section summarizes design criteria for stabilization with brine. These criteria are preliminary and intended for planning purposes. Further refinements during development and pilot testing at the Salton Sea playa would result in refined design criteria that could be incorporated into design efforts.

Criteria presented in these sections pertain to the following:

- Soil conditions;
- Water requirements (quality and quantity);
- Flood flow passage; and
- Irrigation and drainage infrastructure.

Soil Conditions

- Wind conditions that can cause emissions from unstable surfaces are difficult to predict. Therefore, a stable crust should be maintained so that when these conditions arise, they do not result in emissions that violate the Clean Air Act;
- When a playa surface becomes unstable due to crust breakage, salt depletion, or salt mineral transformation, it should be restored to a stable condition through the application of brine;

- Upon wetting, the surface should be stabilized by moisture induced cohesion. After drying, the surface should continue to be stabilized by cohesion within and among stable soil aggregates. This cohesion will be partly due to attractive forces between particles, but cementation by crystalline salts should predominate and result in a much more resistant surface;
- Crust conditions should be tracked based on reliable, field-tested, climate-driven models of Salton Sea playa evaporite (salt) mineral transformations;
- Monitoring should complement models to locate areas where stable crust conditions might be degrading. Remote sensing tools have proven to be of value for this purpose; and
- Operation of infrastructure to repair playa should be timely and localized to address areas before they contribute significantly to playa emissions.

Water Requirements

- The amount of water required to operate stabilization with brine would vary widely within a given year and among years. A preliminary estimate of long term average water requirements is less than 1 foot of water per year, distributed unevenly in time and across the treated area. Peak years might require several times this amount, and minimum years might require a fraction of this amount;
- Should it prove helpful from a playa stabilization or water balance standpoint, supplemental or preventive applications could be made, particularly during warm, dry weather;
- Applications would be where and when monitoring data indicate the need for stabilization;
- Water quality would be the most saline that could practicably be conveyed to and applied to the area of the playa in question. In general, use of Salton Sea water or more concentrated brine would be best to ensure adequate salt concentration and load. Other than the Salton Sea, sources may include subsurface drainage and water stored in the brine pond; and
- In general, stabilized areas are anticipated to be relatively dry and devoid of living vegetation. Therefore, there is little basis or potential for food-chain development. Trace element concentrations in applied water under stabilization with brine, within the ranges observed at the Salton Sea, are not anticipated to cause significant ecological risk.

Flood Flow Passage

- As mentioned previously, water level in the Brine Sink is expected to fluctuate, resulting in intermittent coverage of stabilization with brine areas. The high salt concentrations in the brine pond mean that the water level fluctuation will have a similar effect as applied brine. However, when brine pond levels are high due to storm events, salt concentrations in portions of the standing water may be diluted as compared with the Brine Sink water under normal conditions; and
- Storm flow to the Brine Sink may occur periodically, depending on flood routing and level. When this occurs, stabilization with brine areas may become leached, or lose the soil surface to water erosion. When either occurs, a less saline, poorly cemented surface may be exposed. If this condition is confirmed, brine application to the area (once it is dried) may facilitate crust re-formation.

Irrigation and Drainage Infrastructure

Irrigation in these areas can be by any means that allow for periodic delivery of salt water to the playa surface. Where the perched shallow water table can be raised and the playa is relatively smooth, this process will be facilitated.

Sprinklers are one example for the uniform application of water across the playa. Big-gun sprinklers are capable of spreading water large distances from individual pipeline service outlets, but require higher supply pressures than surface spreading, which is described below. However, pressure can be boosted at the sprinkler intake.

Figure H3-9 shows a typical layout for a brine water spreading operation using a big-gun sprinkler application method.

An alternative configuration of brine water irrigation facilities would supply water at lower pressure from a network of surface outlets. From there, water would flow by gravity on the ground surface and spread across the playa. The objective would again be to supply salt required for rebuilding of salt crust.

Advantages of this approach include the following:

- There is no need to move equipment and tractors around the playa surface where bearing capacity may be low; and
- Booster pump stations are not required, and distribution piping runs at lower pressure.

Disadvantages include the following:

- Distribution piping and appurtenances are more extensive;
- There is less sensitivity (of evaporation losses, salt drift, and uniformity) to wind;
- Distribution uniformity is likely lower, except on windy days;
- Until local shallow groundwater rises, reasonably large areas (local topographic highpoints) may remain unwetted, so that salt crust might not be rebuilt in these areas; and
- More water might be required to accomplish effective spreading and even crust enhancement.

Because selenium levels in exposed sediments may in some areas be elevated, it is possible that wetting these soils at the surface could result in ecological risk through the creation of attractive habitat where high selenium concentrations exist. As discussed above, the primary means of avoiding this condition would be application of water at levels of salinity that are not conducive to development of a viable food chain.

Both irrigation method concepts are retained at this time as alternatives for stabilization with brine. Final decisions regarding irrigation methods can be made based on results of pilot testing of this dust control measure.

Table H3-4 shows working assumptions for irrigation requirements of stabilization with brine. Key assumptions are the amount and timing of required application, and the amount of salt that would need to be delivered to stabilize a surface. Working estimates include an average of 10 percent of the stabilization with brine area treated during a peak month, or about 65 percent of the stabilization with brine area treated in a given year. Assumptions include the following:

- Needed salt would amount to about 5 percent of the upper 3 inches of soil mass;
- Soil intake rates of about 0.5 inch per day (0.02 cubic feet per second [cfs]/acre) are appropriate for fine-textured, massively structured soils on the playa;

- Irrigation efficiency would be about 75 percent;
- Soil bulk density would be about 1.5 grams per cubic centimeter (g/cm^3); and
- Irrigation with seawater would be about 35,000 to 200,000 mg/L TDS.

Table H3-4
Preliminary Working Assumptions for Stabilization with Brine

Item	Value (Seawater)	Value (Brine)	Units
Brine concentration	35,000	200,000	mg/L
	95,200	544,000	lb/acre-foot
Bulk density of crust	1.5	1.5	g/cm^3
	94	94	lb/ft^3
Depth of crust	0.25	0.25	foot
Mass of crust	1,019,935	1,019,935	lb/acre
Percent salt to add	5%	5%	of crust mass
Mass of salt to add	50,997	50,997	lb
Depth of water to add	0.54	0.09	ft
Maximum application rate	0.5	0.5	in./day
	0.02	0.02	in./h
	0.04	0.04	ft/day
	0.02	0.02	cfs/acre
Irrigation efficiency	75%	75%	
Application time	17	3	Days
Average year, peak month	10%	10%	of area
	0.05	0.05	in./day avg over site
	0.002	0.002	cfs/a, avg over site
Peak year, peak month	20%	20%	of area
	0.10	0.10	in./day avg over site
	0.004	0.004	cfs/a, avg over site

Note: More concentrated brine could be available in some locations according to the state of the sea or brine pool source available at the site of and at the time of the implementation

Based on these assumptions, about 0.09 to 0.54 foot of water would be required to provide the needed salt. This could be applied to an irrigated area over about 3 to 17 days without exceeding the target soil intake rates. Actual values relative to these ranges depend on irrigation supply water salinity.

Average year, peak month application rates would be about 0.05 inch per day, averaged over the site. Peak year, peak month assumes that 20 percent of the site would be irrigated, requiring double the average application rate. This latter assumption provides the preliminary design peak flow rate to the overall stabilization with brine area of about 0.004 cfs/acre. Variation throughout the year (as shown in Figure H3-10) is due to seasonal variation in area requiring stabilization with brine. Based on these assumptions, annual applied water is about 0.08 to 0.46 foot per acre of stabilization with brine, depending on salinity of the water supply.

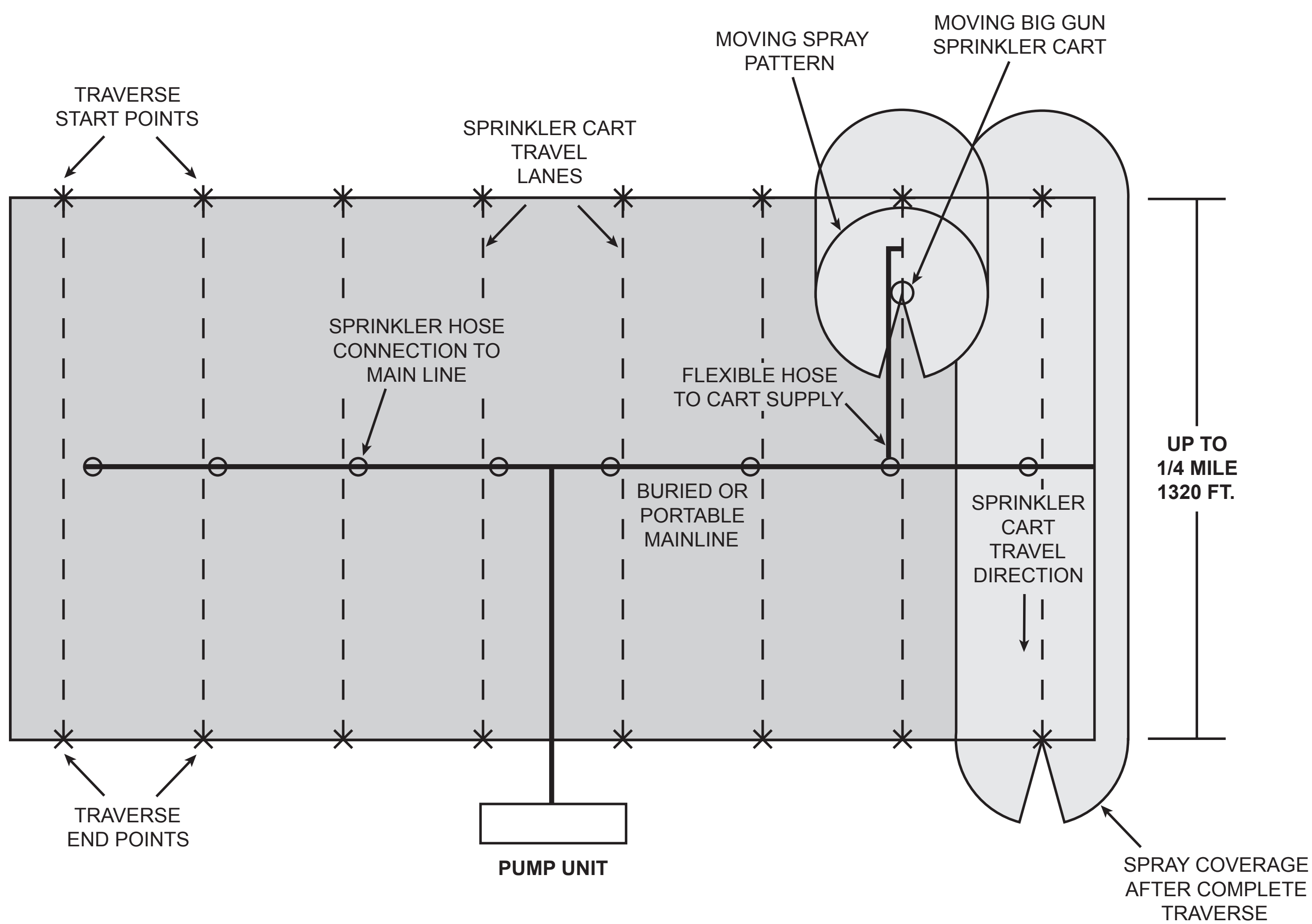

FIGURE H3-9
TYPICAL LAYOUT OF BRINE WATER SPREADING OPTION USING "BIG GUN" SPRINKLER

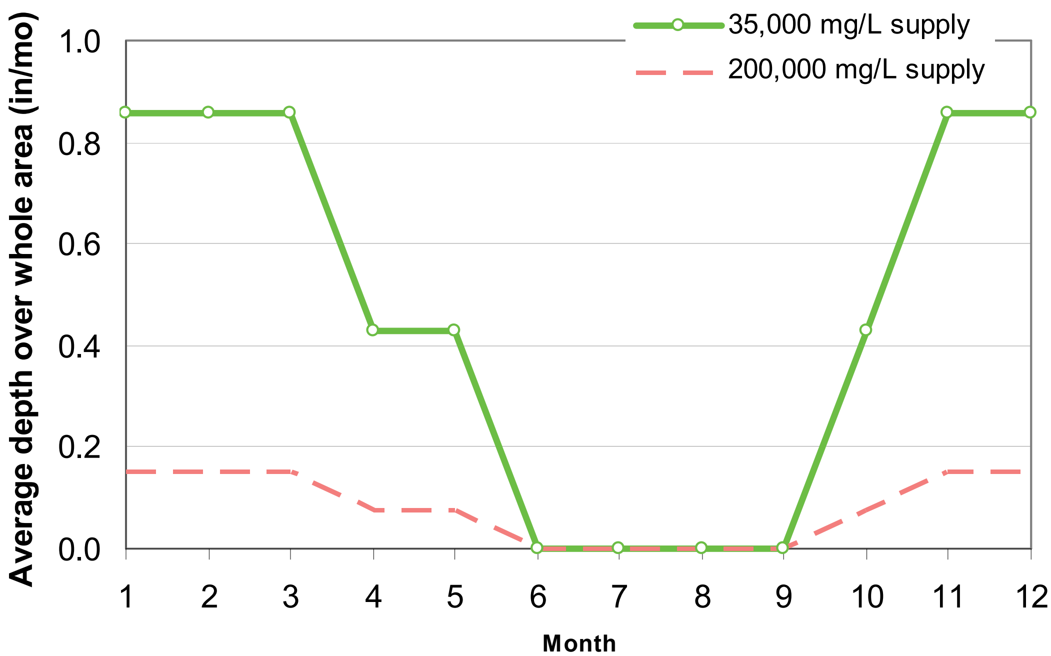

FIGURE H3-10
PRELIMINARY WORKING DISTRIBUTION OF APPLIED WATER THROUGH AN AVERAGE YEAR FOR STABILIZATION WITH BRINE

More site-specific design criteria would be developed for each constructible area at the time of design for that phase. Water requirements would vary according to information available up to the time of the design from more detailed description of the restoration alternative and from project-level field investigations.

Drainage requirements would be minimal and primarily oriented to avoiding offsite impacts of surface and subsurface drainage. Note that runoff represents brine not achieving the intended purpose of application as stabilization with brine. Therefore, minimizing runoff should be the goal, as would be the case for most other irrigation applications. Matching of intake rates to those of the playa and distributing irrigation over the full allotted period should minimize runoff. Also, because discrete areas within the total stabilization with brine area would be treated at any time, much of the runoff would percolate on the remaining stabilization with brine area. Nevertheless, low berms may be useful for retention of runoff at the down gradient margin of the stabilization with brine area, particularly where it is adjacent to sensitive areas, such as water efficient vegetation or habitat. Where a Brine Sink lies down gradient of stabilization with brine, an ideal repository for stabilization with brine runoff will already be in place, and no special measures would be needed to manage runoff.

MONITORING

Short, intermediate, and long term monitoring would provide a basis for making strategic decisions. Several types of monitoring could be used, including hydrologic monitoring, regional aerometric monitoring, and dust source monitoring. Each of these types is briefly described below.

Hydrologic Monitoring

Baseline hydrologic data, as well as groundwater level and soil moisture status over time, would be needed to provide important information for assessing the causes and mechanisms of crust formation and dust emissions. Groundwater evaporation and the subsequent crusting are linked to groundwater levels and geochemistry of source water. At the least, medium term monitoring of groundwater levels and EC in the saturated zone would be needed for estimating salt accumulation at the surface and for evaluating the potential influence of groundwater on dust control measures (for example, water efficient vegetation). The rate of salt transport to the surface via evaporation on open playa could also be modeled with the aid of soil moisture data and could facilitate understanding of natural crust formation rates.

Aerometric Monitoring

Regional aerometric monitoring has been discussed at length in other memoranda. Data generated from this network provide a basis for assessment of air quality, wind fields, evapo-transpirational demand, and precipitation, among others. These data could be employed in models to assess the relationships among the atmosphere and pollution sources and receptors.

Dust Source Monitoring

As playa becomes exposed, dust source monitoring should be implemented. Short term monitoring should first determine whether dust control is required on the emerging areas. This monitoring would involve instrumentation focused on identification of dust source areas on the playa and evaluation of their impact on air quality throughout the area of concern. Sources that tend to cause elevated pollutant concentrations at sensitive receptors, due to their areal scale, location, or emissions intensity, would become the focus of attention.

Areas with a low risk of dust emissions could be transitioned to long term monitoring. Long term monitoring is much less intensive (that is, requires fewer instruments), and designed to verify the dust emissions are not high enough to cause or contribute to exceedance of the applicable air quality standards.

Short and long term dust source monitoring is briefly described in the following sections. Detailed plans for these monitoring networks, including specification of instruments, network layout, and data collection and analysis protocols, could be pilot tested in an upcoming research and development program.

Short Term Dust Source Monitoring

If dust control is needed, the dust control areas would be monitored intensively for 5 years to ensure that they have been stabilized. At a minimum, the monitoring network would consist of the following:

- One remotely operated zoom video camera mounted on a 10-meter tower. The purpose of this instrument would be to record visible evidence of dust emissions within each control area.
- Minimum of four sand motion monitoring stations per square kilometer of dust control area. The purpose of this monitoring would be to record the frequency of sand motion high enough to produce dust emissions. Each sand motion monitoring station would consist of a single real-time Sensit (battery operated) and one passive Cox Sand Catcher (CSC). The data from each station would be collected on a monthly basis, or more frequently if the area is known or suspected to have high sand motion.
- The network would be operated for a period of 3 years after all signs of sand motion or dust emissions within the dust control area have ended. Once a site has been decommissioned, the instrumentation would be moved to another area.

Long Term Dust Source Monitoring

If dust control is not needed on an area, long term air quality monitoring would be implemented to ensure that the dust concentrations leaving the playa are below the PM_{10} standards. Long term monitoring might also be used following the discontinuation of short term monitoring activities on dust control areas.

The recommended long term monitoring network would consist of two upwind and two downwind pairs of real-time dust concentration monitors for each 10 square kilometers of required dust control area. The network would be operated semi-permanently, say, for 5 years after the cessation of all dust plume activity on the playa, or for 10 years after the last recorded evidence of PM_{10} concentrations leaving the playa at concentrations above the standard.

REFERENCES

AeroVironment, Inc. 1992. Owens Lake Phase II Dust Mitigation Studies: Volume 1 of 2. Prepared for Los Angeles Department of Water and Power. April.

Air Quality Group. 1995. Mitigation of Windblown Dusts and Reclamation of Public Trust Values, Owens Lake, California: Partial Mitigation of PM_{10} Episodes through Control of Saltating Particles and Reduction of Wind Shear. Final Report. Contract C9175. Prepared by the Air Quality Group, Crocker Nuclear Laboratory and Department of Land, Air, and Water Resources. University of California, Davis. October 12.

California State Lands Commission. 1984. Results of Test Pilot Studies at Owens Dry Lake, Inyo County, California. Prepared by WESTEC Services. March.

DWR (California Department of Water Resources). 2005a. Salton Sea Ecosystem Restoration Plan. Unified Executive Summary and Appended Final Air Quality Technical Memoranda Prepared to Support the Salton Sea Ecosystem Restoration Plan Programmatic Environmental Impact Report. February.

DWR. 2005b. Description of Air Quality Conditions Under the No-Action Alternative. May.

GBUAPCD (Great Basin Unified Air Pollution Control District). 1996. Owens Valley PM_{10} Planning Area Demonstration of Attainment SIP Projects Alternatives Analysis. Bishop, California. October 23.

GBUAPCD. 1997. Owens Valley PM_{10} Planning Area Demonstration of Attainment State Implementation Plan Final Environmental Impact Report. Bishop, California. July 2.

GBUAPCD.1998. Owens Valley PM_{10} Planning Area Demonstration of Attainment State Implementation Plan. Bishop, California. November 16.

GBUAPCD. 2003. Owens Valley PM_{10} Planning Area Demonstration of Attainment State Implementation Plan. Bishop, California.

IID (Imperial Irrigation District). 2003. Imperial Irrigation District Water Conservation and Transfer Project Mitigation, Monitoring, and Reporting Program,

LADWP. 2000. Final Report: Sand Fence Engineering Feasibility Study: South Sand Sheet Owens Lake Dust Mitigation Program. Prepared by CH2M HILL. September.

Richards, J. 2002.Personal communication to LADWP and CH2M HILL staff regarding plant growth on the Owens Playa.

Richards, J. 2003.Personal communication to LADWP and CH2M HILL staff regarding plant growth on the Owens Playa.

Richards, J. 2004.Personal communication to LADWP and CH2M HILL staff regarding plant growth on the Owens Playa.

Richards, J. 2005. Personal communication to LADWP and CH2M HILL staff regarding plant growth on the Owens Playa.

SWRCB (State Water Resources Control Board). 2002. Revised Order WRO 2002-0013, Revised in Accordance with Order WRO 2002-0016, In the Matter of Imperial Irrigation District's (IID) and San Diego County Water Authority's (SDCWA) Amended Joint Petition for Approval of a Long term Transfer of Conserved Water from IID to SDCWA and to Change the Point of Diversion, Place of Use and Purpose of Use Under Permit 7643 Issued on Application 7482 of Imperial Irrigation District. Adopted by SWRCB on December 20.

Vickerman, D.B., M.C. Shannon, G.S. Banuelos, C.M. Grieve, and J.T. Trumble. 2002. "Evaluation of *Atriplex* Lines for Selenium Accumulation, Salt Tolerance and Suitability for a Key Agricultural Insect Pest." *Environmental Pollution*, 120(2):463-73.

Whiston, K. and J. Powell. 1987. Atriplex canescens—A Quality Shrub. http://uwadmnweb.uwyo.edu/RenewableResources/range/Powell/quality_shrub.htm.

APPENDIX H-3, ATTACHMENT 1

Low-tech Reclamation and Irrigation of Playa

APPENDIX H-3, ATTACHMENT 1 LOW-TECH RECLAMATION AND IRRIGATION OF PLAYA, SUMMARY OF FIELD MEETING JANUARY 2006

On January 12, 2006, Vic Nguyen (Department of Water Resources), Pamela Vanderbilt (CH2M HILL), and John Dickey (CH2M HILL) joined Al Kalin (Imperial County Farm Bureau) for a field meeting around the southern end of the Salton Sea. The purpose of the field meeting was to observe potential emissivity, reclamation, and stabilization of the Salton Sea playa.

For the purposes of these notes, the main areas of discussion are divided among the following topics:

1. Emissivity of Exposed Playa;
2. Using flows during early years to reclaim Salton Sea margins; and
3. Irrigation and drainage on Air Quality Management areas.

EMISSIVITY OF EXPOSED PLAYA

During the day, a number of intermittently flooded areas around the southern end of the Salton Sea were visited. The surfaces ranged as follows:

1. Black alkali in evidence, intermittent patches of loose, puffy soil interspersed with smooth, thin salt crust. This was predominant along the northeastern reach of our tour, near the wildlife refuge;

2. White salt crusting with efflorescent salts. These were extremely common in areas recently flooded by the sea, such as beaches; and

3. White salt crusting without efflorescent salts. This occurred at one site only.

The widespread occurrence of Surface Type 2 is consistent with the characterization of wintertime crust conditions observed around the Salton Sea, and the dust storms described and photographed by Al Kalin in 2005 and 2006. While salt emissions are significant, it is suspected that over large areas, the largest proportion of emissions and largest storms would, if left to occur, likely be predominantly mineral soil erosion, such as we see at Owens Lake. Although efflorescent salts contribute to dust, there is so much more soil mass available below the soft, weak soil surfaces on which these blooms occur, that severe dust storm dust load quickly shifts away from efflorescent salts, which are blown up in the first puff of a big storm. The presence of these crusts is therefore not only significant for the presence of the fluffy salts, but also for the softened crust on which they are formed.

Note that when playas take on this condition seasonally, dust concentrations are still highest where sand is present to drive emissions. The general approach to controlling emissions is not different. However, in some cases, efflorescent salts may contribute to dust emissions where they would not otherwise occur. Eliminating efflorescent emissions may require more intensive control (e.g., denser vegetative cover). This may be justified at playa margins where playa is immediately adjacent to receptors.

The current approach, which acknowledges that a large proportion of the Sea Bed may require active control, and containing contingencies to control the vast majority should this prove necessary, is consistent with seasonally soft crust conditions such as we observed on this trip. DRI testing at the month's end will include some of these sites and may show substantial emissions rates.

Using Flows During Early Years to Reclaim Salton Sea Margins

The objective of reclamation is to remove salt from land before it is dewatered, so that plants will naturally establish, or be easily established by artificial means. Subsequent land uses for any given parcel might be Air Quality Management, or could be something else, like farming. Either Air Quality Management or farming would be facilitated by land reclamation.

Reclamation in inundated conditions may be performed by construction of a temporary (10-20 years) dike in the Salton Sea at the minimum depth (or deeper) at which a dredge can practically operate. The land-ward side of the dike might contain some lateral dikes to facilitate management, and would be supplied with surplus inflows and would eventually become fresh, with the saline Salton Sea outboard. As the outboard subsides, lateral drainage through sediments would be augmented by downward seepage and flushing. Along with substantial wave action and mixing of surface sediments, leaching and mixing would gradually remove salinity from surface sediments within the diked area. Over time, and depending on the nature of local sediments, a proportion of the Salton Sea Bed inboard of the dike would gradually become freshened. When water levels inboard of the dike would eventually be lowered, emergent wetland, and later, upland vegetation, could be established in succession. This process has long been used to "reclaim" sea floor for agricultural uses, most famously in Dutch polders. Although reclamation could also be achieved on the saline playa after the water is removed (as previously discussed for Air Quality Management), polders have advantages where they can be practically employed.

Subsequent temporary dikes would be constructed in a similar manner, sea-ward of the first, as the Salton Sea recedes. If sufficient water remained available for routing through this new set of polders, they could be reclaimed in a similar manner to the first set.

The approach could also be considered for adaptation to construction of lowland features (habitat) in inundated areas.

Potential advantages of polders include:

- Construction in inundated areas, altering, and likely reducing overall air quality issues.
- Replaces initial reclamation effort for exposed land.
- Land vegetated as water recedes, potentially by natural means, eliminating lag period when surfaces would be infertile and exposed.
- Exposed areas could be evaluated and allocated to land uses based on existing and evolving plans and needs.
- Exposed Playa would not initially be saline, and if reclamation is maintained, would not become saline. This would eliminate both stable and unstable playa crusting, as well as efflorescent salt bloom on playa crusts.
- Opportunity to simplify irrigation and drainage infrastructure installed after land is exposed, since playa would not be maintained in a saline condition.

Potential disadvantages include:

- Demand for freshwater supply to empoldered area to reclaim lands (need to be located at times and places when flows are available for routing through the area)
- Time and effort required to empolder and reclaim lands within the polder (needs to be done early in the process before areas are exposed to have maximum benefit)

- Safety and requirement for construction and maintenance of outboard dike; potential instability during seismic events (what would down gradient risks be?)
- Potential for mosquito breeding in fresh water (addressable with mosquitofish?)
- Potential interference with pupfish connectivity (addressable by maintaining adequate water depth in passages near shore?)
- Selenium build-up in the sediment (notes that Fig Lagoon has not presented a problem, although it has remained relatively fresh for some time)
- Cat-tails taking over (primarily a function of water depth and salinity, so should not be an issue in deeper areas)

Irrigation and Drainage on Air Quality Management Areas

Irrigation and drainage technology for reclaimed lands can be viewed on existing farmlands nearby to the Salton Sea. Depending on the nature of the land and the crop, technology varies widely. However, surface irrigation and open drains predominate within IID.

Should the Sea Bed be successfully reclaimed for upland land use, a similarly variable set of soils, drainage (shallow groundwater), and plant community conditions, and therefore irrigation and drainage technology needs, should emerge. Soils beneath the Salton Sea may also include features distinct from what have been terrestrial soils for hundreds of years. Examples include the presence of barnacle deposits, organic matter enrichment, elevated nutrient and selenium content, thick (and likely quite fertile) deltaic deposits, fine-textured shoreline deposits, and (in the lowest lying areas) extremely deep, heavy-textured soils.

When describing irrigation and drainage infrastructure and management for the Exposed Playa, this diversity needs to be clearly acknowledged. Due to the focus on rapid reclamation and vegetation of playa, criteria for irrigation and drainage system performance were far more stringent than would be the case for areas reclaimed in the wet before drainage.

APPENDIX H-3, ATTACHMENT 2

Summary of Information on Water Efficient Vegetation

APPENDIX H-3, ATTACHMENT 2
SUMMARY OF INFORMATION ON WATER EFFICIENT VEGETATION

This appendix contains a summary of methodology for developing a list of salt-tolerant plants suitable for stabilizing the saline Salton Sea playa, along with the resulting list and recommendations.

BACKGROUND

Saline habitats prevalent in the Great Basin and, to a lesser extent, the Mojave Desert, include playas as well as alkaline or saline seeps, springs, wet meadows, and marshes. Playas develop at the bottoms of undrained basins where salts accumulate as a result of runoff collecting and evaporating over geologic time. Alkaline or saline seeps, springs, wet meadows, and marshes support halophytic vegetation that develop around surface expressions of high groundwater tables, or where streamflow spreads and evapo-concentrates.

High temperatures and extreme aridity, related to the location and below sea level elevation of the Salton Sea basin, combine to make it difficult for vegetation to establish and persist without supplemental water. The elevated salinity of the soil exacerbates this difficulty.

METHODOLOGY

The primary factors limiting growth of plants on the Exposed Playa are expected to be elevated soil salinity, impaired drainage (wet soil), drought, and sandblasting. Plants native to the surrounding deserts are therefore indicated, and these are the focus of this investigation.

A preliminary list of native, salt-tolerant plant species suited to the southern low desert region (Lower Colorado Valley subdivision of the Sonoran Desert—also known as the Colorado Desert) was developed, based on available electronic and paper literature. As an indication of tolerance for wet (waterlogged) soil, and (at the other extreme) for drought conditions, the wetland indicator status of plants on the initial list was determined. Species with strong wetland affinities were removed because they might require too much water. For the remaining plant species, wetland indicator status was employed as an indicator of tolerance of poor drainage, as shown in Table H3-2-1.

Table H3-2-1
Wetland Classes as Indicators of Drainage

Wetland Indicator Class	Salton Sea Drainage Tolerance Rating
FACW	1
FAC+	2
FAC	3
FAC*	3
FACU	4
OBL	5
UPL	6
NI	7

FAC Facultative Plants
FAC* Facultative Plants (status tentative)
FAC+ Facultative Wetland plus
FACU Facultative Upland Plants
FACW Facultative Wetland Plants
NI No Indicator
OBL Obligate Wetland Plants
UPL Obligate Upland Plants

Literature was further searched for data on salt tolerance of listed species, with a focus on quantitative indications. Based on these data, species were sorted about into salt-tolerance classes. First, the available information on salt tolerance was applied to provisionally assign plants to high, moderate, and low salt-tolerance categories. This assignment was based primarily on quantitative information and supplemented by qualitative descriptions of habitat and salt tolerance. The classic U.S. Department of Agriculture (USDA) salt-tolerance classifications were then extended with the addition of new subdivisions of the "tolerant" class, including "tolerant," "very tolerant," and "extremely tolerant." This extension allowed for differentiation among the many tolerant species on the preliminary list. Salt-tolerance classes are shown in Table H3-2-2.

Table H3-2-2
Salinity-Tolerance Classes (adapted from USDA)

Class Name	Salton Sea Salt Tolerance Rating
Extremely tolerant (ET)	1
Very tolerant (VT)	2
Tolerant (T)	3
Somewhat tolerant (ST)	4
Moderately sensitive (MS)	5

The lists of species were then divided among (1) recommended species (based on habitat affinities, salt tolerance, and likelihood of success as restoration plantings) and (2) species not recommended for initial consideration. Species not recommended were either deemed less suitable for the playa due to lower reported salt tolerance, or placed in this category pending availability of more information supporting their suitability for establishment.

FINDINGS

A relatively limited subset of salt-tolerant plants found in the Mojave and Great Basin deserts occurs in the Salton Sea region. The more extensive lists of salt-tolerant plants found in these deserts may result from the prevalence of moist, saline habitat and slightly cooler temperatures (due to the higher elevations and more northerly latitudes) outside of the Salton Sea Watershed. The species identified in the table as "recommended" generally have the ability to survive under such harsh conditions, once they are established.

Table H3-2-3 shows the list of identified species, their wetland indicator status and narrative salt-tolerance information, and initial recommendation. The classification and ranking as to "worst case" drainage and salinity tolerance for each species are also shown. Listed species were sorted hierarchically by salt and drainage tolerance to provide a general ranking as to suitability for planting Air Quality Management on the Exposed Playa. The exact order of this ranking is approximate due to the approximate nature of the methodology and underlying data. However, the general ranking order captures gross differences in suitability, so that high, moderate, low, and very low groups on this ordered list should be valid. *Atriplex* spp. and *Suaeda moquinii* constitute the upper ranking group of species. Several of these species have been grown successfully on the Owens Lake Playa, and a substantial amount has been learned about their growth requirements.

Table H3-2-3
Salt Tolerant Plants and Adaptation to Salton Sea Playa Conditions

Name	Wetland Indicator Status	Preliminary Salt Tolerance Classification	Salt Tolerance Comments	Habitat Affinities, Range, and Notes	Final Salt Tolerance	Drainage Rating	Salinity Rating	Suitability Rank
Species Suitable for Planting in Saline Soils								
Parry's saltbush	FACW	High?	"Salt tolerant" (1)	This species inhabits saline washes and dry lakebeds of the Mojave and Sonoran Deserts (3).	ET	1	1	1
quailbush; big saltbush	FAC	High	Can grow in full-strength sea water (35,000 ppm) or saltier; has survived in Mediterranean Sea water (56dS/m), but productivity decreases above 16 dS/m (1)	This species is present on alkaline or saline washes, dry lakes, and shrubland within the Desert Province (3). It generally inhabits alkaline places in the Mojave and Colorado Deserts (2). This species is common in salty soils in the area surrounding the Salton Sea (11).	ET	3	1	2
Bractscale	FAC	High	Can grow in full-strength sea water (35,000 ppm) or saltier; has survived in Mediterranean Sea water (56dS/m) (1)	This species inhabits alkaline flats of the Mojave Desert, Sonoran Desert, and Baja California (3).	ET	3	1	2
bush seepweed, Mojave seablite	FAC	High	Tolerant to at least 35,000 ppm (56dS/m)	This species is located in the Desert Province and exists in alkaline and saline places and within intermittently flooded shrubland and facultative upland association (3). It is common in salty soils in the area surrounding the Salton Sea.	ET	3	1	2

Table H3-2-3
Salt Tolerant Plants and Adaptation to Salton Sea Playa Conditions

Name	Wetland Indicator Status	Preliminary Salt Tolerance Classification	Salt Tolerance Comments	Habitat Affinities, Range, and Notes	Final Salt Tolerance	Drainage Rating	Salinity Rating	Suitability Rank
fourwing saltbush	FACU	High	Very tolerant. Has been grown at 37,000 ppm (more than sea water) and in oil shale with 59 dS/m (1); tolerant of salt levels between 2 and 6% (7)	This species is present from the South Mojave to Salton Sea area (2) within the Desert Province (3). Habitat type is shrubland with clay to gravelly flats (3). This species is common in salty soils in the area surrounding the Salton Sea.	ET	4	1	3
Allscale	FACU	High	Tolerates to 54.7 dS/m (1); tolerant of less than 2% salt (7)	This species is common in the Desert Province with alkaline flats and dry lakes (3). It can grow in poorly drained soils (1) and is common in salty soils in the area surrounding the Salton Sea.	ET	4	1	3
wormwood, poverty weed	FAC	Moderate?	"Salt tolerant" (1)	This species is present throughout California in many saline habitats (3). *Iva axillaris* inhabits alkaline plains, edges of salt marshes, cultivated fields, pastures, roadsides, and waste places. It often grows on poorly drained, heavy alkaline or saline	VT	3	2	4
alkali goldenbush	NI	Moderate	Co-occurs with species of *Atriplex* (11) and *I. menziesii* has high salt tolerance (12)	This species exists within the Desert Province of California on sandy or clay soils in alkaline or gypsum flats and slopes (3). It is common in salty soils in the area surrounding the Salton Sea.	VT	7	2	

Table H3-2-3
Salt Tolerant Plants and Adaptation to Salton Sea Playa Conditions

Name	Wetland Indicator Status	Preliminary Salt Tolerance Classification	Salt Tolerance Comments	Habitat Affinities, Range, and Notes	Final Salt Tolerance	Drainage Rating	Salinity Rating	Suitability Rank
alkali mallow	FAC*	High?	High salt tolerance (12)	This species is considered a noxious weed in Jepson, although native to the USA (3) and it is common in salty soils in the area surrounding the Salton Sea (11). This species is common in Imperial County and they do not enforce any restrictions or regulations for its dispersal (21). *M. leprosa* inhabits many plant communities in semi-arid to arid regions, also orchards, crops, pastures and roadsides. It often grows on moist, alkaline to saline soils (22).	T	1	3	5
Additional Species for Consideration								
alkali sacaton	FAC+	Moderate?	Estimated to be tolerant (20)	This species is found in the Desert Province in seasonally moist, alkaline places (3).	T	2	3	6
Silverscale	FAC	High?	“Salt tolerant” (1): occurs in saline soils (3)	This is an annual species present in the Desert Province of California (3). It thrives in moist alkaline and saline soils in sagebrush scrub and juniper woodland communities (2).	T	3	3	7
salt heliotrope	OBL	Moderate	Can handle half-strength sea water (more or less 20 ppt) (1)	This species is present throughout California in moist to dry, saline soils (3).	T	5	3	8

Table H3-2-3
Salt Tolerant Plants and Adaptation to Salton Sea Playa Conditions

Name	Wetland Indicator Status	Preliminary Salt Tolerance Classification	Salt Tolerance Comments	Habitat Affinities, Range, and Notes	Final Salt Tolerance	Drainage Rating	Salinity Rating	Suitability Rank
desert-holly	UPL	Moderate	Somewhat lower tolerance than other *Atriplex* spp. (1); occurs in alkaline flats (2) tolerant of less than 2% salt (7)	This species is common to shrubland on dry slopes and alkaline flats and washes within the Desert Province (3).	T	6	3	9
Lycium andersonii	UPL	Moderate	Some degree of facultative salt tolerance and can grow in highly saline and alkaline places (10)	This species resides on gravelly or rocky slopes and washes of the Californian Desert Province (3).	T	6	3	9
skeleton weed, spiny goldenbush	FACW	Low?		This species is generally found in the Sonoran Desert near seeps, moist stream sides, ditches and sometimes saline or drier areas (3).	ST	1	4	10
western sea-purslane	FACW	Moderate?	Some salt tolerance (6)	This species is present in the Desert Province and inhabits the margins of saline wetlands and flats (3); and it is common in salty soils in the area surrounding the Salton Sea (11).	ST	1	4	10
lowland Purslane, horse-purslane, desert horsepurslane	FACW	Moderate	Some salt tolerance (1 and 6)	This species is found in the Desert Province near moist or seasonally dry wetlands (3).	ST	1	4	10
screwbean mesquite	FAC	Low	Some resistance to salt (14) ; Somewhat salt tolerant (13)	This species in located in the Desert Province of California and resides in sandy or gravelly desert washes, creeks, and ravines (3).	ST	3	4	11

Table H3-2-3
Salt Tolerant Plants and Adaptation to Salton Sea Playa Conditions

Name	Wetland Indicator Status	Preliminary Salt Tolerance Classification	Salt Tolerance Comments	Habitat Affinities, Range, and Notes	Final Salt Tolerance	Drainage Rating	Salinity Rating	Suitability Rank
arid tansyaster, Silver Lake daisy	FACU	Low	*M. xylorrhiza* is tolerant of 6 to 8 mmhos (8)	This species is found in the Desert Province of California near riverbanks, sandy, alkaline flats and along roadsides (3).	ST	4	4	12
honey mesquite	FACU	Low	Can occur in saline places (1); moderately salt tolerant (5); somewhat salt tolerant (13)	This species is present within the Desert Province of California in grassland habitats, alkali flats, washes, bottomlands, sandy alluvial flats, and mesas (3).	ST	4	4	12
net pepper-grass, alkali pepperweed	OBL	Moderate		This species is found is saline soils, dry streambeds and fields throughout California (3).	ST	5	4	13
blue palo verde	UPL	Low	Can tolerate at salinity of at least 10 dS/m (15)	This species exists within the Sonoran Desert in washes and flood plains (3).	ST	6	4	14
black-stem	UPL	Low	Unknown, other species of *Chysothamnus* have moderately high to high (=6 to 10 mmhos) tolerance (8)	This species grows in gravelly washes of the Desert Province of California (3).	ST	6	4	14
desert thornapple, Small Datura, desert thorn-apple	UPL	Low?	Plants of *D. stramonium* subjected to 7000 ppm produced more fruit than plants grown at lower salinity (16)	This species is found in the Sonoran Desert in sandy, gravelly soils and washes (3).	ST	6	4	14

Table H3-2-3
Salt Tolerant Plants and Adaptation to Salton Sea Playa Conditions

Name	Wetland Indicator Status	Preliminary Salt Tolerance Classification	Salt Tolerance Comments	Habitat Affinities, Range, and Notes	Final Salt Tolerance	Drainage Rating	Salinity Rating	Suitability Rank
Mormon tea	UPL	Low	High salt tolerance for all species (9); can tolerate up to 10 mmhos (8)	Seven species exist in CA according to Jepson and five are located in throughout the Desert Province. All are present in creosote-bush scrub and/or Joshua tree woodland. *E. trifurca* is the only sp specifically designated in Sonoran Desert.	ST	6	4	14
cheeseweed, burrobrush	UPL	Low?	Some salt tolerance based on its co-occurrence with *Atriplex* species (10)	This species is present in Southwestern California and Desert Province and resides in dry flats, washes, and fans (3).	ST	6	4	14
lineleaf whitepuff, oligomeris, leaved cambess	UPL	Moderate?	Some salt tolerance (1); grows on salt flats (17)	This species is common in the Desert Province along rocky slopes, open dunes and alkaline places (3).	ST	6	4	14
Colorado River hemp	FAC	Low	Moderately sensitive (20)	This species is found in the Sonoran Desert along streams and other moist places (3).	MS	3	5	15

CULTURAL CONSIDERATIONS

Establishment under natural conditions may occur only under an extremely infrequent combination of environmental circumstances that provide adequate soil moisture for growth and establishment, and may also reduce surface salinity temporarily, alleviating stress on the germinating and establishing seedling. Cultural practices that increase the potential for seedling survival are required for reliable establishment when planting in saline soils. Such practices may include leaching with irrigation water to reduce soil salinity, long term irrigation if planted at high densities (as may be required for dust control), and drainage to facilitate removal of highly saline shallow groundwater and leachate from the root zone. Where large plantings occur in isolated locations, protection of seedlings from herbivores is not likely necessary. However, smaller plantings accessible to herbivores might require protection. Methods for this that involve no fencing or poison have been developed at Owens Lake.

Many of the species on the recommended list, such as four wing saltbush (*Atriplex canescens)*, are widespread. However, to ensure adaptation to local conditions, it would be important to propagate material from populations native to the immediate vicinity of the Salton Sea. Development of adequate amounts of material (seed or cuttings) for planting may require large-scale propagation efforts.

CONCLUSION

To better define which species are likely to be successful candidates for dust control, further investigation will be helpful. However, based on this preliminary investigation, establishing a persistent cover of salt-tolerant shrubs that can survive under projected conditions of temperature, moisture, and salinity appears feasible.

SUMMARY OF INFORMATION FROM OWENS LAKE ON WATER EFFICIENT VEGETATION

Much of what is known about growing salt tolerant vegetation to stabilize playas comes from experience at Owens Lake. This information was used to develop design criteria for water efficient vegetation on the Salton Sea playa. This section summarizes some of the Owens lessons, and is provided here as supporting information for that section.

GENERAL POINTS ABOUT GROWING SALT TOLERANT, WATER EFFICIENT VEGETATION TO STABILIZE PLAYA

Where plant, soil, and water management questions arise in agriculture due to the cultivation of new lands or the introduction of a new crop, conventional research techniques are applied to the problem to provide farmers with the scientifically-based production information that they need to succeed. This requires funding, time, planning, and trained scientists (agronomists, soil scientists, agricultural engineers and the like). Research at Owens Lake has shown that the same package can very efficiently provide high-quality information for vegetation of a playa. Standard research techniques employ replicated experiments, statistically representative plot and sampling layouts, and plots just large enough to reliably represent conditions of concern. Key resources in planning, designing, and executing this work can be drawn from among the plant, soil, and water system specialists at, for example, the USDA Agricultural Research Service and University of California. These resource persons' activities need to be carefully coordinated with dust control goals, information needs, and schedule.

Methods for collection, propagation, and priming of native saltgrass seed were developed for Owens Lake over the span of a couple of years. Seed gathering from native stands, planting of seed production fields, and laboratory experimentation with priming were undertaken concurrently. All of these ventures proved fruitful, and together they produced viable seed in excess of that needed for planting of managed vegetation. Conceptually, similar techniques could be applied to other species, such as salt-tolerant desert shrubs.

LESSONS LEARNED ABOUT SALTGRASS AND SALT-TOLERANT SHRUBS AT OWENS LAKE

Experience at Owens Lake and other sites, along with a tight schedule, led to an early focus on saltgrass. While quite salt tolerant and reasonably effective as a ground cover, saltgrass is a wetland plant. This makes it reasonably tolerant to soil waterlogging, unless this is combined with high levels of salinity (as happens on the playa). It also makes it less tolerant of drought and more demanding of irrigation than desert shrubs with similar adaptation. An early and exclusive emphasis on saltgrass meant that other species with perhaps equivalent or superior long term potential were excluded from consideration in dust control effectiveness and agronomic research. This made saltgrass the only choice at the time of construction of vegetative dust control in 2001.

When alternative species were investigated in greater depth through focused, small-plot research, it was found that they tolerated playa growth conditions better than saltgrass and grew at least as quickly. They have the added advantage of producing large individual plants, so that planting densities and cost of establishment are lower. Lastly, they tolerate moving sand with less compromise to vegetative cover.

LESSONS ABOUT IRRIGATION AND DRAINAGE FROM OWENS LAKE

Restricted drainage is the major limiting factor on heavy textured playa soils that with some exceptions are understood to dominate Salton Sea sediments. Early research at Owens Lake focused on surface irrigation and open drains, which while less costly than many other methods of irrigation, are poorly suited to playa irrigation. First, the open drains are prone to filling with sand, and do not adequately drain highly stratified, heavy textured soils. Second, surface irrigation results in larger leaching fractions and drainage loads, increasing the inadequately drained playa area under any given drainage system. Therefore, irrigation should be efficient and required reclamation leaching achieved with the lowest possible depth of percolating water.

The overwhelming influence of drainage, therefore, resulted in employment of drip irrigation and a rather extensive subsurface drainage system. Surface conditions, including periodic floods, high winds, and extreme fluctuations in temperature, led to the choice of subsurface installation of drip tubing. Concerns over plugging of drip tubing due to water quality (primarily due to high scaling potential) or root intrusion, and over the ability of subsurface drip tubing to thoroughly leach overlying soil, were outweighed by surface condition considerations. Subsurface drainage spacings were approximate, and French drains or additional underdrains were later added to augment drainage of the wettest areas. This combination of subsurface drainage, subsurface drip, and adaptive management of irrigation rates and drainage facilities has been extremely successful in making virtually the whole planted area hospitable to plant establishment and growth.

Blending of inflows with saltwater may be required for irrigation of playa (see discussion below in Lessons about Soil and Water Quality Management from Owens Lake). Drip irrigation with blended water requires construction and operations and maintenance of filtration and water treatment (anti-scaling) facilities. These are not unlike facilities employed for, say, vineyard irrigation, but may require more intensive water quality management due to lower water supply quality and the effects of blending. Water quality management could be primarily centralized (before conveyance to turnouts serving large areas of playa), or located at major turnouts from the main supply line. In the latter case, a pressurized saltwater supply line to each turnout may be required. At Owens Lake, where the source of saltwater is recycled subsurface drainage (used to blend for irrigation of drainage, or to feed playa flooding facilities), blending is done at the turnouts. At Salton Sea, where the Sea provides a ready source of saltwater, centralized blending may be preferable.

On a per-acre basis, subsurface drip irrigation and drainage systems are more costly than simpler alternatives, but substantial soil, plant, and water problems associated with implementation of other irrigation methods on saline playas (and costs to manage these problems) are avoided.

LESSONS ABOUT SOIL AND WATER QUALITY MANAGEMENT FROM OWENS LAKE

Stable soil structure must be maintained for sustainable irrigation and drainage of vegetated areas. In much of irrigated agriculture, the balance between calcium, magnesium, and sodium are maintained to avoid unwanted degradation of this balance, which results from a preponderance of sodium. However, this approach can prove impractical on playas due to their large capacity to supply sodium. An alternative approach taken at Owens Lake managed vegetation has been successful to date. This entails blending of saltwater with fresher water to produce irrigation water at the highest target salinity threshold that can be tolerated by salt-tolerant plants. In this more saline condition, soils are much less prone to degradation due to the predominance of sodium over calcium and magnesium.

LESSONS FROM OWENS LAKE ABOUT PLANT COVER REQUIREMENTS FOR ADEQUATE DUST CONTROL

Wind-tunnel experiments were the basis for specification of the required percent vegetative cover at Owens Lake. A conservative 50 percent cover was selected, partly to deal with uncertainty in application of the broader literature to Owens Lake conditions, and partly due to uncertainty about the limited Owens-specific research that existed at that time. Preliminary monitoring results from large-scale, established vegetative dust control on Owens Lake now suggest that less than half this amount of cover may provide adequate control.

Playa soils are extremely variable, intensely saline and sodic, and prone to waterlogging and (potentially) to degradation of soil structure. Properly designed and implemented, irrigation and drainage can reliably create acceptable growing conditions on most of the playa. However, even at high levels of investment, some areas are recalcitrant to reclamation and will not grow plants. The size of these areas can be minimized when irrigation, drainage, and plant husbandry are handled properly. At Owens Lake, minimum vegetative dust control coverage requirements were specified for application to every acre. Practically, specifying conditions at this small a scale is incompatible with playa soil variability, and has the effect of greatly increasing the capital and operations and maintenance cost of facilities. It is also not clear that this level of uniformity is required for effective dust control. The necessity of the 1-acre criterion for effective dust control is under review for these reasons.

SIGNIFICANT DIFFERENCES BETWEEN OWENS LAKE AND SALTON SEA PLAYAS

These lessons, being recent, local to California desserts, and specific to dust control on a playa land surface, can be very valuable in planning Air Quality Management for the Salton Sea. However, conditions on the Exposed Playa differ in a number of important ways from those that prevail at

Owens Lake playa. These differences must also be considered when evaluating the suitability and optimal configuration of vegetative control for the Exposed Playa. A summary of some of the key differences is as follows:

- Salton Sea's water surface still covers most of its playa. Exposed Playa would emerge gradually around the perimeter of the dewatered area, and only a portion of it would not be covered and controlled by some other means;
- Dust control would likely take three major forms:
  - Temporary dust control that can be implemented swiftly in response to problems either before an area is buildable, or in specific areas not otherwise controlled;
  - Relatively large units of permanent dust control facility construction; and
  - Refinement, modification, and optimization of permanent dust control facilities and operations.
- Driving forces for dust emissions, such as wind and mobile sand, may be substantially less intense or frequent on the Exposed Playa as compared to the Owens Lake playa;
- Due to generally warmer winters, resistance to dust emissions posed by stable playa crusting may prove more consistent on the Exposed Playa than on the Owens Lake playa;
- After initial dewatering, large areas of the playa may be less influenced by shallow groundwater fed by artesian sources. Taken by itself, this factor facilitates drainage. However, it is noted that where soils are irrigated in nearby Imperial Irrigation District, drainage loads are higher, but subsurface drainage is almost ubiquitous due to poor natural drainage conditions;
- The Exposed Playa may have a greater predominance of finer textured soils, and of soils and strata with extremely low permeability. Taken by itself, this factor makes drainage more challenging;
- Native species occurring on the Exposed Playa differ some from those at the Owens Lake playa. In general, many of the species considered for Owens Lake also occur at the Salton Sea, both areas being California deserts; and
- The invasive species pressure may be greater on the Exposed Playa than on the Owens Lake playa. *Tamarix* control for subsurface drip irrigated shrubs would be expected to be less than for measures involving extensive surface wetting.

APPENDIX H-3, ATTACHMENT 3

Unit-area Water Demands

APPENDIX H-3, ATTACHMENT 3
UNIT-AREA WATER DEMANDS

Evaporative water demands are an important part of the project-wide water budget. These demands can vary widely from the relatively dry surfaces of Air Quality Management irrigated desert shrub areas to the cattail wetlands of natural treatment systems and to open water surfaces. The purpose of this document is to provide a consistent framework for estimating water demands across the various elements. The first section presents a review of reference evapotranspiration data from around the Salton Sea while the second section focuses in on water demand estimates for each element.

Calculations for this memo are available on request.

CIMIS ET_0 DATA ANALYSIS

Evaporative water demands are affected by a number of factors including solar radiation, air temperature, relative humidity, wind speed, and surface characteristics. A standardized measure of the atmospheric potential for evaporation at a given location is reference grass evapotranspiration (ET_0). The ASCE standardized Penman-Monteith equation is widely accepted as the standard method for estimating ET_0 and is the methodology used by the California Department of Water Resources for the California Irrigation Management Information System (CIMIS) network of micrometeorological stations across the state.

There are twelve active CIMIS stations within 50 miles of the Salton Sea. However, only seven stations are located within 15 miles of the Sea and only four of these are reference ET_0 stations, meaning they are surrounded by irrigated vegetation thus making their climate measurements valid for use in ET_0 calculations.

Data from two CIMIS sites on the northern shoreline of the Salton Sea and two sites on the southern shoreline of the Salton Sea were evaluated to determine whether ET_0 is significantly different from north to south. Basic station metadata from the four stations is provided in Table H3-3-1 with specifics on measurements collected at each station provided in Table H3-3-2.

Table H3-3-1
CIMIS Station Metadata

	Brawley (Calipatria/Mulberry)	Oasis	Mecca	Westmorland North
Station Number	#41	#136	#141	#181
Nearest City	Calipatria	Oasis/Indio	Mecca	Westmorland
Activation Date	17-Jul-83	1-Feb-97	5-May-98	1-Apr-04
Elevation (ft)	-110	12	-180	-200
Latitude	33 deg 3 min N	33 deg 32 min N	33 deg 32 min N	33 deg 5 min N
Longitude	115 deg 25 min W	115 deg 9 min W	115 deg 59 min W	115 deg 40 min W
Reference Surface	Irrigated Grass	Irrigated Grass	Irrigated Grass	Irrigated Alfalfa
Comments	Located on a large flood irrigated grass field	Located on a 100 x 100 ft area of turf grass surrounded by strawberry fields	Located on a well maintained turf grass farm field	Located on a flood irrigated alfalfa field

Table H3-3-2
IMIS Station Measurements

Parameter	Frequency	Location/Size
Air temperature	Daily max/min	1.5 m (4.92 ft) height
Precipitation	Daily total	20 cm (8 in) diameter gauge
Soil temperature	Daily max/min	15 cm (6 in) depth
Humidity	Daily max/min	1.5 m (4.92 ft) height
Solar radiation	Daily global radiation	2 m (6.5 ft) height
Wind speed & direction	Daily average	2 m (6.5 ft) height

Southern Stations

The two southern stations that were evaluated were Brawley and Westmorland North. Westmorland North has a much shorter period of record (1 year) than the Brawley station (22 years) but is located closer to the Salton Sea shoreline. ET_0 measurements from the two stations over a 12 month period (April 2004 through March 2005) were within 2 percent of each other with the Brawley station estimating slightly higher ET_0. Due to the significantly longer period of record of the Brawley station, ET_0 results from this station were used to characterize conditions around the southern portion of the Sea.

Northern Stations

The Mecca and Oasis stations were evaluated to characterize evaporative conditions representative of the northern portion of the Salton Sea. These two stations are located within 10 miles of each other and are both within three miles of the Salton Sea. Although there were some significant data gaps in each data set, data was available from one or the other station for the entire period from February 1997 through March 2005. During periods of data overlap, ET_0 estimates were very similar between the two stations. Consequently, monthly ET_0 was averaged between the two stations for months in which three or fewer days of data were missing from the record to provide one monthly ET_0 estimate for northern stations.

Northern and Southern Station Comparison

The ET_0 data representative of southern Salton Sea conditions (Brawley CIMIS station) and the northern Salton Sea conditions (average of Mecca and Oasis CIMIS stations) were compared over the more limited period of record available from the northern stations (February 1997 through March 2005). The average northern ET_0 (72.01 inches per year) was higher than southern ET_0 (68.14 inches per year) during each month of the year for the period evaluated. Because of the limited record and the relatively minor differences between the two datasets, however, statistical differences were only weekly significant. At the 95th percentile confidence interval, only April ET_0 was significantly higher in the north. At the 80th percentile confidence interval, January, April, July, and December ET_0 were significantly higher in the north. On an annual basis, northern ET_0 was about 5.7 percent higher than southern ET_0.

With the period of record available at Brawley (southern ET_0) being much longer than any of the other stations and the distribution of ET_0 throughout the year being uniform across stations, the Brawley data is used for all the remaining evaporative demand calculations. To correct water demands from the southern Sea based values to northern Sea values, an adjustment factor of 5.7 percent can be used.

Brawley ET_0 Distribution

For the sixteen years of complete data sets at Brawley, annual and monthly statistical ET_0 distributions were developed. Complete data sets were defined by three or fewer missing days in each month of the year. The average annual ET_0 was 71.34 inches per year and ranges from less than 64.04 inches per year to greater than 78.65 inches per year for 20 year return intervals. ET_0 statistics by month are also presented in Table H3-3-3. The highest variability from year to year in monthly ET_0 occurs during the winter months of November through February when ET_0 is the lowest.

Other climatic variables measured at Brawley that are important for evaporative water demand calculations are average wind speed at a 2 meter height and minimum daily relative humidity. The monthly average 2 meter height ranges from 4.0 to 5.6 miles per hour (mph). The ET_0 weighted average 2 meter height is 5.1 mph. The monthly average relative humidity ranges from 17.2 to 36.2 percent. The ET_0 weighted average relative humidity is 24.9 percent.

WATER DEMANDS

Evaporative water demands for each element are an important part of the project-wide water budget. Water demands for each water budget element are presented in the following sections.

Air Quality Management

Air Quality Management components of the water budget consist primarily of subsurface drip irrigated desert shrub vegetation. This vegetation would be established over historical Sea Bed surfaces exposed from the receding shore line. The total plant cover in these areas would be about 25 percent and the dominant shrub would likely be an *Atriplex* (saltbush) species. In order to prevent the rise of saline shallow groundwater into the shrub root zone, artificial subsurface drainage would be used.

Air Quality Management water demands can be separated into reclamation demands and maintenance demands. Reclamation water demands occur during the first year of irrigation and are used to flush the initial high salt concentrations out of site soils prior to planting of the permanent vegetation. These demands are estimated to be similar to the reclamation irrigation demands during the first year of saltgrass establishment on Owens Lake of about 24 inches or 2 ac-ft/ac.

Ongoing maintenance water demands are comprised of three major components: 1) consumptive use (evaporative losses); 2) irrigation inefficiency resulting in non-effective leaching; and 3) salt leaching fraction resulting in effective leaching and removal of salts from the root zone.

The consumptive use for *Atriplex* was estimated using crop coefficient curves developed by Steinwand et al. (2001) and the ET_0 data from Brawley. Irrigation application efficiency was estimated at 95 percent for subsurface drip irrigation and the leaching ratio was estimated at 5.3 percent based upon a maximum irrigation water electrical conductivity (EC) of 7.5 dS/m and a management allowed root zone soil saturated paste EC_e of 30 dS/m. Resulting water demand estimates are provided in Table H3-3-4. Based on average monthly conditions, the annual gross irrigation requirement is about 13.78 inches (1.15 ac-ft/ac). The average year gross irrigation water requirement partitions into 12.44 inches of consumptive use and 1.34 inches of drain return flows. The annual gross irrigation requirement varies from 12.37 inches (1.03 ac-ft/ac) to 15.19 inches (1.27 ac-ft/ac) for the 5th and 95th percentile years. The annual drain return flows vary from 1.21 inches (0.10 ac-ft/ac) to 1.48 inches (0.12 ac-ft/ac) for the 5th and 95th percentile years. The peak monthly gross irrigation requirement in June is about 3.53 inches for an average year.

Calculations based on the above assumptions were re-done to reflect a target EC of 10 dS/m. Leaching and irrigation requirement are increased by about 0.25 inches.

Table H3-3-3
Monthly ET_0 Distributions at Brawley

		January	February	March	April	May	June	July	August	September	October	November	December	Annual
Minimum	[in]	1.63	2.29	4.40	6.17	7.57	8.46	7.78	7.39	5.75	4.44	2.42	1.45	65.11
Maximum	[in]	3.10	4.28	6.36	8.04	9.58	10.86	10.97	10.32	9.28	5.93	3.99	3.34	82.48
Mean	[in]	2.41	3.25	5.41	6.97	8.68	9.17	9.15	8.69	7.12	5.13	3.09	2.28	71.34
Median	[in]	2.54	3.25	5.30	6.80	8.65	9.11	9.14	8.68	7.09	5.11	3.01	2.31	70.17
Standard Deviation	[in]	0.49	0.48	0.56	0.55	0.52	0.64	0.67	0.65	0.76	0.46	0.41	0.40	4.44
Coefficient of Variation	[%]	20%	15%	10%	8%	6%	7%	7%	8%	11%	9%	13%	18%	
5th Percentile	[in]	2.16	2.92	4.85	6.26	7.79	8.23	8.21	7.80	6.39	4.61	2.77	2.05	64.04
10th Percentile	[in]	2.22	2.99	4.98	6.42	7.99	8.43	8.42	8.00	6.55	4.72	2.84	2.10	65.65
25th Percentile	[in]	2.31	3.11	5.18	6.68	8.32	8.78	8.76	8.33	6.82	4.92	2.96	2.18	68.35
50th Percentile	[in]	2.41	3.25	5.41	6.97	8.68	9.17	9.15	8.69	7.12	5.13	3.09	2.28	71.34
75th Percentile	[in]	2.51	3.39	5.63	7.26	9.05	9.55	9.53	9.06	7.41	5.35	3.22	2.38	74.34
90th Percentile	[in]	2.60	3.51	5.84	7.53	9.38	9.90	9.88	9.38	7.68	5.54	3.33	2.46	77.03
95th Percentile	[in]	2.66	3.58	5.96	7.68	9.57	10.10	10.08	9.58	7.84	5.66	3.40	2.51	78.65

Table H3-3-4
Air Quality Management (Air Quality Management) Water Demands

	Average Conditions			5th Percentile			95th Percentile		
Month	ET-Air Quality Management (in)	Gross IWR (in)	Drain Return Flow (in)	ET-Air Quality Management (in)	Gross IWR (in)	Drain Return Flow (in)	ET-Air Quality Management (in)	Gross IWR (in)	Drain Return Flow (in)
January	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00
February	0.04	0.05	0.00	0.04	0.04	0.00	0.05	0.05	0.00
March	0.26	0.29	0.03	0.24	0.26	0.03	0.29	0.32	0.03
April	0.93	1.03	0.10	0.83	0.92	0.09	1.02	1.13	0.11
May	2.23	2.47	0.24	2.00	2.22	0.22	2.46	2.72	0.27
June	3.18	3.53	0.34	2.86	3.17	0.31	3.51	3.89	0.38
July	3.01	3.33	0.32	2.70	2.99	0.29	3.31	3.67	0.36
August	1.88	2.08	0.20	1.69	1.87	0.18	2.07	2.30	0.22
September	0.71	0.79	0.08	0.64	0.71	0.07	0.78	0.87	0.08
October	0.17	0.18	0.02	0.15	0.17	0.02	0.18	0.20	0.02
November	0.02	0.03	0.00	0.02	0.02	0.00	0.02	0.03	0.00
December	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Annual	12.44	13.78	1.34	11.17	12.37	1.21	13.71	15.19	1.48

Habitat

The habitat component still needs to be defined in discussion with wildlife refuge managers. Important factors influencing water demands for this model component will be the relative fractions of dry area, open water, and emergent wetland vegetation areas throughout the year as habitat areas are managed to provide different types of habitat throughout the year.

WATER RESOURCES

The water resources component of the water budget consists of open water surfaces of varying salinity and depth. These open water surfaces consist of water in conveyance channels, evaporation ponds, and the isolated northern and southern lobes of the Salton Sea. Salinity levels may vary from below 2,000 mg/L salinity in the New and Alamo rivers to above 300,000 mg/L in evaporation ponds. Water depths range from inches to in excess of 50 ft.

Evaporation from free water surfaces can be estimated in a number of different ways including catchment level water budgets with correlation to pan evaporation measurements or ET_0, use of floating evaporation pans, or by energy budget methods. Energy budget methods are considered fairly accurate when water temperature data are available for model calibration. However, these data are not available at the Salton Sea nor are floating evaporation pan measurements. Relations between pan evaporation or ET_0 and open water evaporation over deep water is only reliable on a coarse time scale like annual evaporation. During periods of the year when the large water mass is heating, evaporation will be lower than projected with a constant pan evaporation or ET_0 factor and during periods of water cooling, actual evaporation rates will be higher.

Recent studies use approximate open water surface evaporation estimates for the Salton Sea from Weghorst (2001) and Weghorst (2004). These estimates are based on a U.S. Geological Survey report by Hughes (1967). In general, the estimated net evaporative water demand (evaporation minus precipitation) for Salton Sea water with a TDS concentration below 44,000 mg/L averages 68.99 inches per year or 5.75 ac-ft/ac per year. Salinity effects on evaporation are minimal at these salt concentrations but start becoming significant as salinity increases above this range.

Air Quality Management Water Requirement Calculations

Local meteorology and Air Quality Management system characteristics were considered, and unit water requirements for Air Quality Management were estimated for average, dry, and moist years. Following are tables showing the following:

- A summary of results for water efficient vegetation, including blending requirement for a given saltwater inflow salinity;
- Monthly water requirements for water efficient vegetation; and
- Monthly water requirements for Shallow Flooding.

REFERENCES

Allen, R.G., L.S. Pereira, D. Raes, and M. Smith. 1998. *Crop Evapotranspiration: Guidelines for Computing Crop Water Requirements.* FAO Irrigation and Drainage Paper No. 56. Food and Agriculture Organization of the United Nations, Rome, Italy.

Hughes, G.H. 1967. *Analysis of Techniques Used to Measure Evaporation From Salton Sea*, California, USGS Geological Survey Professional Paper 272-H.

Steinwand, A.L., R.F. Harrington, D.P. Groeneveld. 2001. *Transpiration Coefficients for Three Great Basin Shrubs*. Journal of Arid Environments, 49:555-567.

Weghorst, P.A. 2001. *Salton Sea Accounting Model*. U.S. Bureau of Reclamation Lower Colorado Region.

Weghorst, P.A. 2004*. Salton Sea Salinity Control Research Project*. U.S. Bureau of Reclamation and the Salton Sea Authority.